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CONGENITAL PSEUDARTHROSIS

Treatment by Dual Bone Grafts *

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The purpose of this paper is to discuss congenital pseudarthrosis and to suggest a method of treatment by homogeneous dual bone grafts.

Congenital pseudarthrosis occurs in the lower half of the leg. The typical findings of the condition in this location form a specific surgical entity. Rarely, congenital bone defects may be found in other locations, but the condition discussed in this paper will be limited to those occurring in the lower half of the tibia or in the tibia and fibula.

Several theories have been advanced regarding the etiology of congenital pseudarthrosis. The most probable are: congenital defect in the tibia, resulting from a deficiency in the germ cells; congenital absence of the nutrient artery of the tibia; and fracture through a bone cyst, followed by non-union. Either of the first two may well account for a congenital defect in the tibia. Pseudarthroses which develop after birth are probably due to bone cysts. These cysts have been described by Wade, Inglis, Compere, Scott, and others. Scott reported a case illustrated by serial roentgenograms, showing the tibia before the cyst was demonstrable, followed by the development of the cyst, fracture of the tibia, and formation of the pseudarthrosis. The cyst was first noted in the cortex of the anterior border of the tibia. As a cyst develops, the tibia gradually bends forward, producing the anterior bowing usually seen in this condition. Fracture occurs following slight trauma or spontaneously.

The formation of cysts, followed by fracture, can be conclusively demonstrated in some cases, and is a plausible theory in others. The theory of congenital absence of a segment of the tibia seems to fit the facts more closely in patients without evidence of cyst formation in the roent-

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genogram, and with long tapering ends on both the proximal and distal fragments of the tibia.

Pathologically and roentgenographically the cysts seen in the tibia resemble those evident in localized osteitis fibrosa, but the cysts in the two conditions behave differently following fracture. There is practically no effort on the part of the body toward spontaneous healing of the fracture in the congenital cases, whereas healing with callus formation is the rule following fractures through cysts in patients with osteitis fibrosa. Osteitis fibrosa (bone cysts) have a predilection for the upper third of the femur, humerus, or tibia, while the cysts predisposing to pseudarthrosis are seen in the lower half of the tibia.

Congenital pseudarthrosis appears to be a purely local condition. In reported studies, blood calcium and blood phosphorus have been within normal limits. There is no relation between this condition and the Wassermann reaction. None of the patients in our series had a positive Wassermann. Colonna reported a patient with congenital pseudarthrosis, who had three operations before coming to him. Three additional bone grafts were done; all were failures and the leg was eventually amputated. During this period of treatment, the child sustained two traumatic fractures in the unaffected leg; both of these united normally. The supramalleolar osteotomies for valgus of the ankles, done in Case 1 of this series, united in a normal period of time.

Barber has called attention to a relation existing between congenital bow legs, pseudarthrosis, and von Recklinghausen's neurofibromatosis. Moore has also discussed the relationship of neurofibromatosis to orthopaedic conditions. Two of the four patients reported in this paper exhibited areas of pigmentation similar to the "*café au lait*" spots reported by these authors (Cases 1 and 2).

Camurati classifies pseudarthrosis of the tibia in three clinical types: latent, fixed, and mobile. In the first, there is no break in continuity of the tibia. The leg is usually curved anteriorly. The diaphysis is atrophied and shortened, and the medullary canal is partially or entirely obliterated. In the fixed type there is a dense connective tissue, bridging the pseudarthrosis of the tibia, and the fibula is intact. In the mobile form, an osseous defect is present in both the tibia and fibula. The anterior curvature of the tibia usually forms an acute angle. The ends of the fragments may be hook-shaped or pointed.

From this classification it is difficult to differentiate the "latent" group from congenital bowing of the tibia. The prevalence of pseudarthrosis following osteotomy of congenital bowing of the tibia and the extreme difficulty of securing union following such a pseudarthrosis suggest that the etiology in congenital pseudarthrosis and congenital bowing of the tibia may be related.

Practically, the patients can be divided into two groups,—those born with a defect in the tibia and those who develop a pseudarthrosis after birth. In the latter, the fracture is usually noted some time during the

first two years of life, and occurs secondary to a bone cyst, or is due to a fracture in the latent type.

Camurati, in 1930, reported twenty-seven cases and collected 118 from the literature. Of the 145 cases, 57.6 per cent. of the patients were males; 95.5 per cent. of the cases were unilateral. Ninety-seven of the patients had been treated surgically; of these, thirty, or 31 per cent., were cured; and twenty-one of the thirty cures followed bone grafts.

In the English literature, Henderson, Wade, Colonna, Compere, Hallock, and McFarland have reported a total of twenty-six patients treated surgically. Of these, thirteen, or 50 per cent., obtained union. A total of seventy-four operations were performed on the twenty-six patients,—an average of two and eight-tenths operations per patient. This number includes the operations performed on the patients before they were referred to the surgeons reporting the cases. The percentage of unions reported in the literature is probably higher than that usually obtained, as one rarely takes the trouble to report a series of failures. From these data one may conclude that there is no other condition in which bony union is so difficult to obtain as in congenital pseudarthrosis; however, these data also show that union is obtainable.

Success is primarily dependent upon the age of the patient and the efficiency of the operative procedure. It is the consensus that the older the patient, the better the chance of securing union. Camurati states that surgery should not be attempted under the age of six years. Henderson advises one well-planned operation in childhood and, if this fails, the postponement of further surgery until puberty. From the reported cases, it is evident that union is more easily obtainable in the older patients. If union can be obtained in young children, the end results should be much better, as the deformity and shortening of the leg associated with congenital pseudarthrosis increase as the child grows. When union is obtained in a young child, function and weight-bearing during the growth period predispose to a more normal development of the bone and leg. This is well illustrated in Case 1, reported in this paper.

Surgery offers the only practical method of obtaining union. If one wishes to postpone surgery because of the age of the patient, the lower extremity should be fitted with a leather lacer brace to support the leg and to prevent increase in the deformity. The age at which operation should be done is difficult to determine. The ages of the patients reported in this paper at the time of bone grafting were two and one-fourth years, four and one-half years, five years, and seven years. Since failure is common in young children, it is probably wise to postpone surgery until the child is five or six years of age. If the surgeon has the cooperation of the parents, a proper brace worn until this age will prevent gross deformity.

Many types of operations have been recommended. Incision through or "osteotomy" of the pseudarthrosis, followed by manipulation and immobilization in a cast, may assist in the correction of deformity, but is of no value in securing bony union.

Excision of the pseudarthrosis, exposing normal bone on each fragment, followed by apposition of the fragments with sutures and external immobilization, has resulted in too small a percentage of unions to warrant this procedure. It also necessitates wide resection of bone; this increases the shortening which is usually already present.

The percentage of unions following the use of osteoperiosteal grafts has been too small to recommend their use.

Hallock has used multiple bone chips to fill a gutter extending across the pseudarthrosis and into normal bone in each fragment. His results have been good. The small multiple grafts furnish excellent osteogenesis, but internal fixation is not obtained.

McFarland has described an ingenious "by-pass" bone graft. He reports two cases with union in each case. In this procedure, no attempt is made to correct the deformity. The graft is completely surrounded by soft tissue, which may be a theoretical disadvantage.

The massive onlay graft has been the operation of choice in this country and a fair percentage of success has followed its use.

Experience has demonstrated that the best end results in the treatment of non-unions following traumatic fractures have followed the use of the massive onlay graft, as described by Henderson or Campbell. Two principles are employed in each of these procedures. Secure internal fixation is obtained by means of a cortical tibial graft. Osteogenesis is promoted by packing cancellous bone about the fracture site.

Union in this condition is much more difficult to secure than in non-union following traumatic fractures. Faced with this fact, the surgeon should use more effective bone grafts in the treatment of congenital pseudarthrosis than in patients with ordinary non-unions. In an effort to do this, the technique of the dual graft as described was devised. The case reports illustrate how the dual graft was developed.

In Case 1, an onlay bone graft was employed. The graft was removed from the mother's tibia. Due to the small size of the child's bones, silver-wire loops were used to secure the graft, in place of autogenous bone pegs. This procedure was used four times in three patients. In one (Case 1) a union was obtained; the other three operations resulted in absorption of the graft and non-union. Thus, this procedure was successful in one-third of the patients and one-fourth of the operations. One of the other two patients is now an adult with non-union; the other had an amputation following the failure of the second graft.

With the development of vitallium screws, it was felt that they would secure better fixation of the graft than the wire sutures had. In Case 2, a massive tibial graft removed from the mother was employed and vitallium screws were used for fixation. Cancellous bone was packed about the fracture site. In this child, union was obtained but, in retrospect, there are two points of criticism. First, in congenital pseudarthrosis the bone may be too soft to enable the threads in the vitallium screws to secure a firm grasp. Second, although a large amount of cancellous bone

was packed about the fracture site, this bone was compressed by the organizing and contracting scar tissue which forms postoperatively about the fracture site. This results in a hemi-hour-glass constriction at the site of union and a diminution in the size of the tibia at this point. This constriction predisposes to refracture and hinders the establishment of a marrow cavity through the former site of pseudarthrosis. This hemi-hour-glass type of union also occurs in cases where a defect in bone is bridged with an onlay graft and the defect is filled with cancellous bone. These factors are especially marked where the bone fragments are pointed at the ends, as in Case 3. To overcome these objections it was decided to use the dual bone graft. The advantages of this method are:

1. Better mechanical fixation is obtained.
2. The tibial grafts are revascularized slowly, and provide rigid internal fixation over a long period of time.
3. The cancellous bone about the fracture is revascularized quickly and produces a strong osteogenic element.
4. With a single graft, the screws may fail to hold in osteoporotic bone. With the dual graft, a clamp is formed which compresses the tibial fragments between the two grafts.
5. The grafts form a trough to hold the cancellous bone which is packed around the fracture.
6. The grafts prevent compression of the cancellous bone by contracting fibrous tissue during the healing process. Hemi-hour-glass constriction of the bone at the fracture site is minimized.
7. The diameter of the grafted bone is increased.
8. Partial absorption of one graft does not necessarily result in refracture and failure, as the second graft maintains internal fixation.

TECHNIQUE OF THE OPERATION

A full-thickness tibial graft of suitable size (usually about nine inches long and three-quarters of an inch wide) is removed from the tibia of the mother or father. The endosteal bone is then cut with a motor saw from the cortical portion of the graft. Additional cancellous bone is removed from the upper end of the tibia with a curette. The cortical portion of the graft is divided at its center. This provides two cortical grafts about four and one-half inches long and an ample supply of cancellous bone.

The pseudarthrosis is then exposed through a long anterior incision. The connective tissue forming the pseudarthrosis is excised. The eburnated bone which covers the ends of the fragments is removed. Care is taken to conserve all the leg length possible. The medullary canal of each fragment is opened with a drill. The deformity is then corrected and, if necessary, the tendo achillis is lengthened through a second incision. If an associated defect in the fibula is not present, it may be necessary to osteotomize this bone.

A bed is prepared for the grafts on the medial and lateral surfaces of the tibia. Just enough bone is shaved from the sides of the tibia to insure

denuded areas for the grafts and a slightly flattened surface to receive them. In the expanded areas in the tibia at a distance from the pseudarthrosis, it is necessary to remove more bone to receive the graft than in the region of the pseudarthrosis. Considerable space may remain between the grafts at the fracture site. This is especially true if the ends of the fragments are pointed. This is not a disadvantage as the space is filled with cancellous bone. The narrow portion of the tibia is thus increased in size.

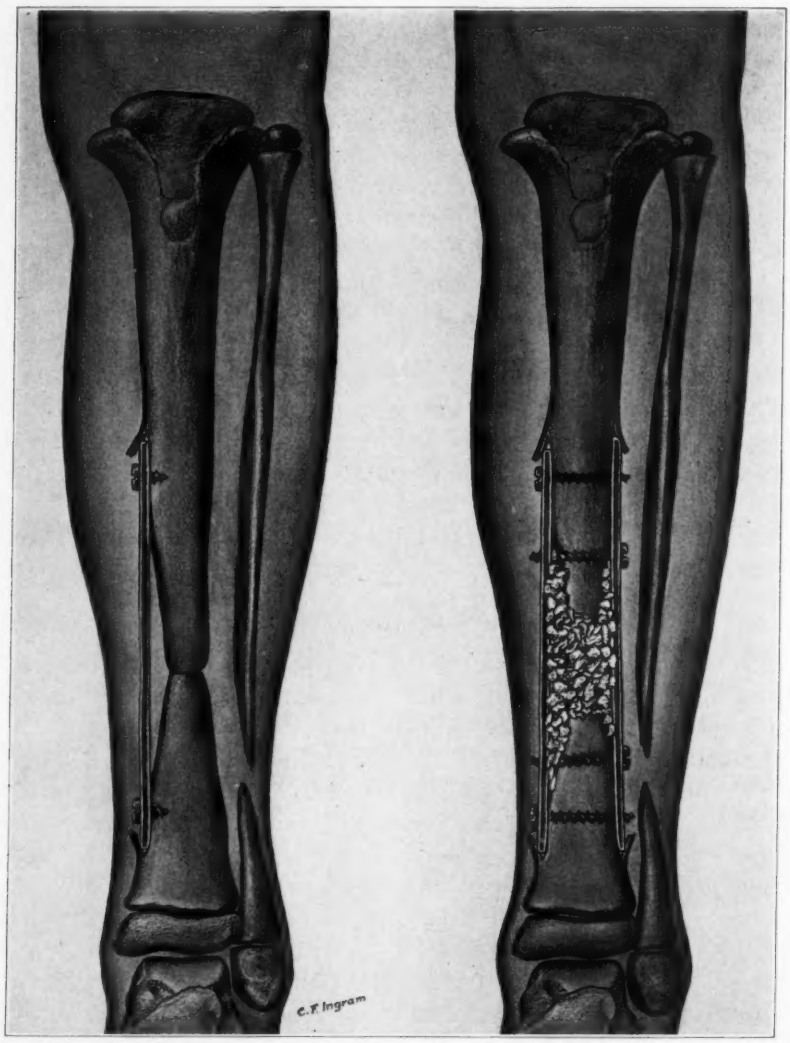

FIG. 1-A FIG. 1-B

Fig. 1-A: The first graft has been applied and is held in position by two temporary vitallium screws.

Fig. 1-B: Both grafts are in position and held by means of vitallium screws which pass through both grafts and the intervening bone. The temporary screws have been replaced by the permanent screws.

The grafts should extend as far down the tibia as possible without causing damage to the lower tibial epiphysis. The graft should extend for an equal distance or more above the fracture site. The longer the graft the better, and, in small children, it may extend to the upper tibial metaphysis.

One graft is placed on the inner or outer surface of the tibia and held by two short temporary vitallium screws. The second graft is then placed on the opposite side of the tibia and two long vitallium screws passed through the graft, the grafted bone, and the first graft. The short screws are then removed one at a time and replaced by long screws which pass through both grafts and the intervening bone (Figs. 1-A and 1-B).

The screws should not be placed too close to the fracture site. This error was made in the upper screw in the lower fragment of Case 3. As in all bone-grafting procedures, the drills should be of the proper size for the screws. The screws must be of the proper length to reach through the second graft. Screws of smaller diameter would be an advantage for use in children. As non-electrolytic machinable metals are developed, such screws should be available.

The trough, formed by the two grafts and the space about the pseudarthrosis, is then packed with cancellous bone. The entire space, both posterior and anterior to the pseudarthrosis, should be filled. This is an important step in the operation, as cancellous bone is a powerful osteogenetic factor.

The skin and subcutaneous tissue are then closed with interrupted silk sutures. No effort is made to close the deep fascia, as there is not sufficient soft tissue available after the application of the dual graft. The leg is immobilized in a cast from groin to toes.

Immobilization in casts is continued until union is demonstrable in the roentgenogram. A leather lacer brace is then fitted. These braces are made from a plaster mold of the leg and have no joint at the knee or ankle. Weight-bearing is permitted in the brace. Use of the brace is continued until a new marrow cavity has formed, connecting the proximal and distal fragments through the former area of pseudarthrosis, and until the size and density of the tibia approach the normal. This period of immobilization may be several years. The leg may be removed from the brace for bathing and to permit motion in the knee and ankle. Weight-bearing without the brace should not be permitted sooner than indicated above, as union following refracture may be as difficult to obtain as in untreated cases.

Valgus deformity of the ankle is usually seen in cases presenting a congenital defect in the fibula. This deformity increases with growth. Care should be taken to correct as much of the valgus as possible at the original operation. Bilateral supramalleolar osteotomies for correction of valgus deformity of the ankles were done in Case 1, as stated in the case report. A similar operation will be required in Case 3 at a later date.

Objections may be raised to the use of homogeneous grafts. Autog-

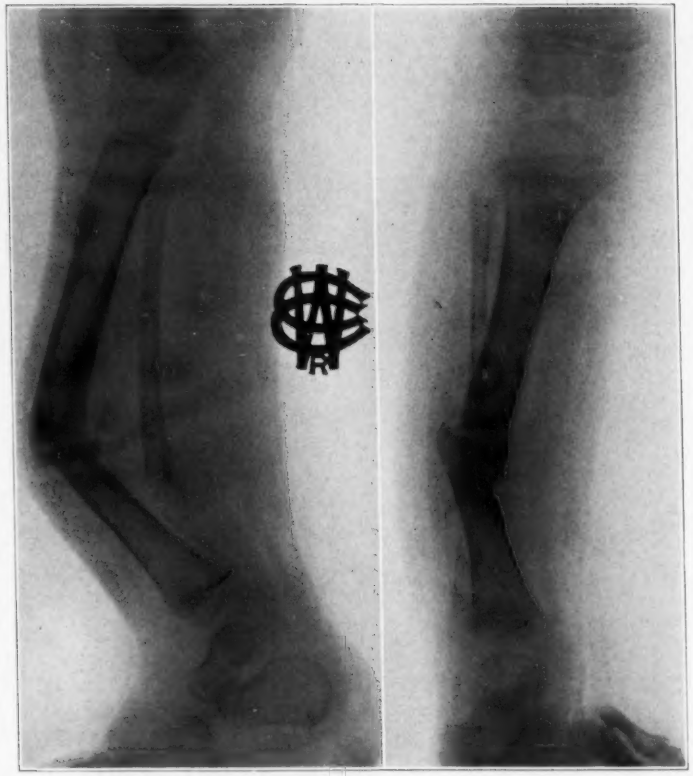

FIG. 2-A

Case 1. Preoperative roentgenograms, showing congenital pseudarthrosis of the right tibia with an associated defect in the fibula.

FIG. 2-B

Case 1. Union seven months after onlay bone graft. Silver wire was used for fixation of the graft. Bony union is present. A new medullary canal has not been established across the fracture site.

FIG. 2-C

Case 1. Roentgenograms taken fifteen years postoperatively. The shaft of the tibia is of normal size and density. The defect in the fibula is still present.

FIG. 3-A

Case 2. Preoperative roentgenograms showing congenital pseudarthrosis of the right tibia with associated defect in the fibula.

FIG. 3-B

Case 2. Roentgenograms taken four months postoperatively show solid bony union of the graft to the proximal and distal fragments, with beginning union at the fracture site.

enous grafts are preferred, but in children it is difficult to secure sufficient bone for a good onlay graft, and impossible to obtain enough for a dual graft. Practically, the homogeneous grafts have worked out nicely in the cases reported. The blood groupings of the bone donors and the patients are recorded for interest. It probably makes little difference whether the patient and the bone donor are of the same blood group, as bone is transferred, not blood. Alan De Forest Smith reported successful homogeneous grafts from bone donors in whom the blood grouping was not the same as that of the recipient, as well as in instances where the blood was compatible. Whether or not bone types exist may be determined in the future.

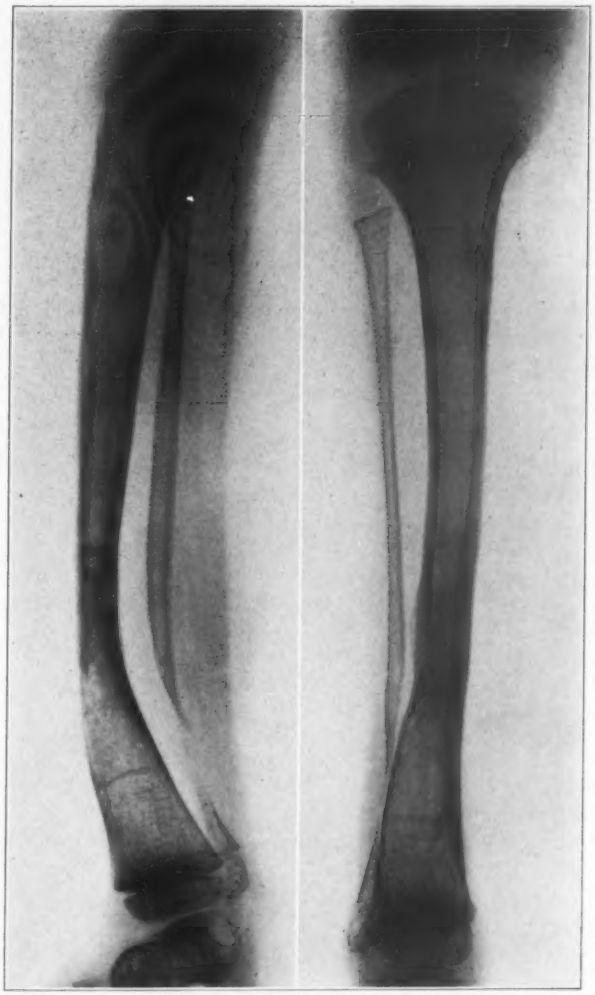

FIG. 3-C

Case 2. Roentgenograms taken eighteen months postoperatively. There is solid bony union. A new medullary canal has been established across the fracture site. Defect in the fibula is still present. Note the "hour-glass constriction" at the fracture site.

CASE REPORTS

CASE 1.* S. A., white female (Campbell Clinic No. 15366), was first seen on July 6, 1925, at the age of twenty-seven months. The anterior bowing of the leg was noticed during infancy, and fracture of the right tibia was first discovered at the age of fifteen months. The patient was placed in a cast for four weeks, and a brace for six months. The anterior and lateral bowing of the lower one-half of the tibia and fibula gradually increased. On admission, pseudarthrosis was demonstrated clinically and roentgenographically. In addition to the pseudarthrosis of the tibia, there was a defect in the

* Dr. Willis C. Campbell performed the bone graft on this child. The author is indebted to him for permission to include this patient in the series.

fibula (Fig. 2-A). From history and roentgenographic findings, the pseudarthrosis was probably secondary to a bone cyst.

July 10, 1925: A massive onlay bone graft was done, using a tibial graft from the mother. Six circular silver-wire loops were used to fix the transplant to the tibia. Cancellous bone was packed about the fracture site. The mother's and patient's blood were of the same group and compatible.

August 21, 1925: The wound had healed by primary intention, and a new cast was applied.

February 13, 1926: A roentgenogram showed that bony union had occurred, but that a medullary canal had not been established across the fracture site (Fig. 2-B).

May 22, 1926: Cast immobilization was replaced by a brace.

July 6, 1926: Roentgenograms revealed solid bony union. A new medullary canal was being formed through the fracture site. The silver wires were removed.

October 9, 1926: The patient was developing a slight knock-knee deformity, for which splints were fitted. Roentgenogram showed solid bony union. A new medullary canal had been established.

May 20, 1937: There was a valgus of 30 degrees of the right ankle, and 25 degrees of the left ankle (valgus of the left ankle was due to a congenital pseudarthrosis in the lower end of the left fibula). A supramalleolar osteotomy for correction of this deformity was advised.

February 22, 1938: A supramalleolar osteotomy was done to correct the valgus of the right ankle.

September 27, 1938: A supramalleolar osteotomy was done to correct the valgus deformity of the left ankle.

Following these procedures, both osteotomy sites healed normally.

October 22, 1940: At the age of seventeen, fifteen years after the bone graft, the right lower extremity was of the same size and strength as the left, except for three-eighths of an inch of shortening on this side. Roentgenographic examination revealed the right tibia to be of the same size and contour as the left (Fig. 2-C). Approximately 10 degrees of valgus of the ankles were still present. There was normal range of motion in the joints of both lower extremities. The patient walked without a limp, and carried on normal activities for a girl of her age. She stated that she was not handicapped in any way by her former pseudarthrosis.

CASE 2. H. L., a white male (Campbell Clinic No. 41036), first seen on May 25, 1937, at the age of two and one-half years. False motion and angulation of the lower third of the right tibia and fibula were present at birth. One operation for correction of the deformity had been done at the age of nine months. On admission, anterior bowing of the leg with free motion at the fracture site was present. Roentgenograms showed pseudarthrosis of the tibia and fibula.

June 21, 1937: The tendo achillis was lengthened and Hallock's operation was performed. The multiple chip grafts were removed from the mother's ilium.

July 25, 1938: Roentgenograms showed absorption of the chip grafts. There was free clinical motion at the pseudarthrosis (Fig. 3-A).

March 2, 1939: An onlay bone graft (from the mother's tibia) secured with vitallium screws was performed and cancellous bone packed about the fracture site. The mother's blood group was the same as the child's.

June 30, 1939: Roentgenograms revealed union of the graft to the proximal and distal fragments, and apparent beginning union at the site of pseudarthrosis (Fig. 3-B).

November 18, 1939: Roentgenograms revealed bony union at the site of the congenital pseudarthrosis. There was a tendency toward hemi-hour-glass constriction at the fracture site. A new medullary canal had not been established.

March 5, 1940: Roentgenograms showed union at the fracture site and beginning formation of a medullary canal.

May 10, 1940: The vitallium screws were removed under local anaesthesia.

September 26, 1940: Roentgenograms showed that the medullary canal had been

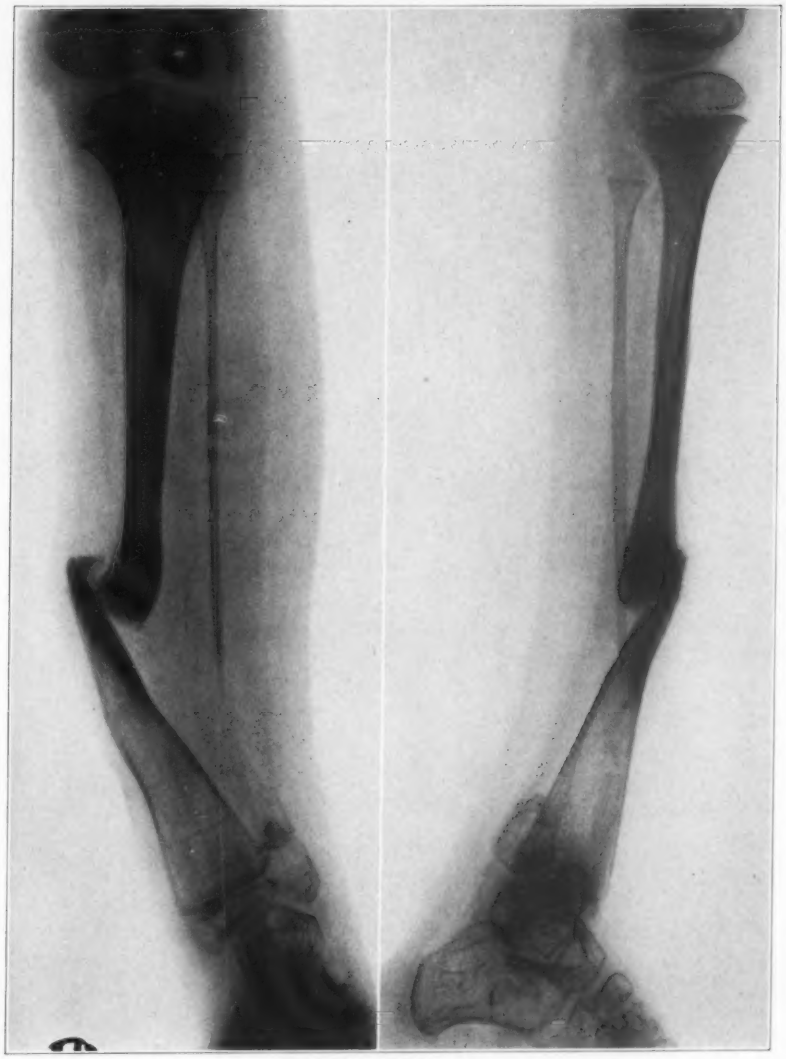

FIG. 4-A

Case 3. Preoperative roentgenograms show congenital pseudarthrosis of the left tibia with associated defect in the fibula.

established between the proximal and distal fragments. There was still a constriction at the fracture site (Fig. 3-C). The affected extremity was three-eighths of an inch shorter than the normal one.

CASE 3. W. J. W., white female (Campbell Clinic No. 46921), first seen on July 19, 1939, at the age of five years. Fracture in middle third of the left tibia was present at birth. A bone graft, using the fibula from the other leg, had been done at the age of one year. This was followed by cast immobilization for three years. On admission, there was anterior and medial bowing of the tibia and definite non-union both clinically and roentgenographically (Fig. 4-A). The left lower extremity was three-eighths of an inch shorter than the right.

July 22, 1939: Dual bone grafts were applied, using tibial bone from the father.

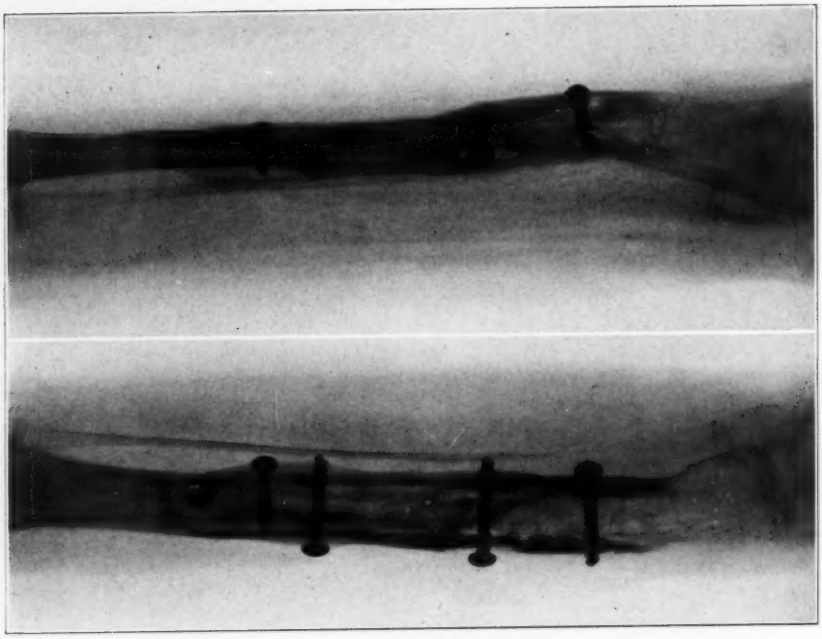

FIG. 4-C

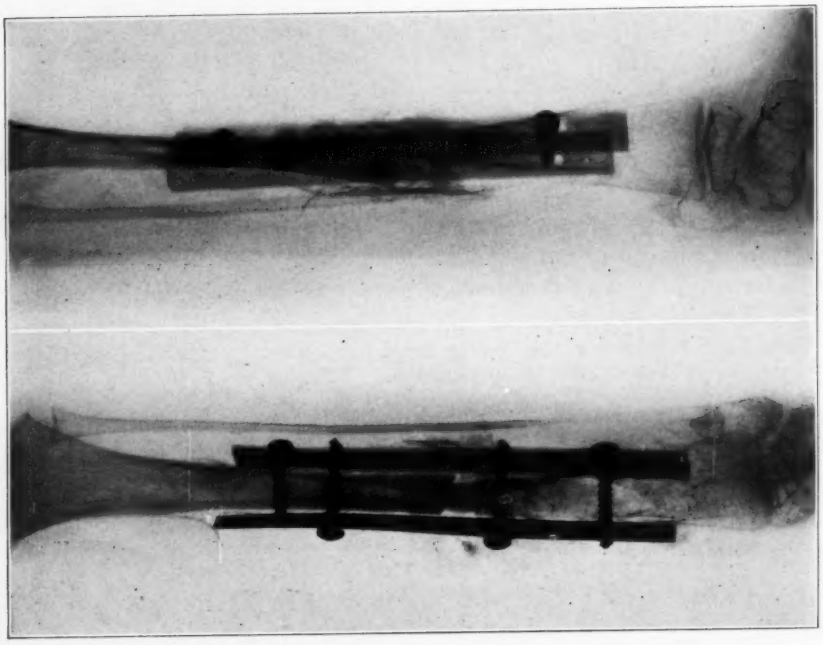

FIG. 4-B

Cancellous bone was packed about the fracture site and between the grafts (Fig. 4-B). The patient's blood grouping was Type IV; the father's was Type II, and not compatible.

September 8, 1939, and *January 26, 1940:* The cast was changed. Roentgenograms, taken on the latter date, showed absorption about the head of one of the screws in the tibial graft on the medial side (Fig. 4-C).

February 19, 1940: The screw mentioned above was removed under local anaesthesia and a new cast was applied.

April 5, 1940: A walking cast was applied.

May 14, 1940: The cast was removed. The fracture was clinically solid. A jointless leather lacer brace from groin to toes was fitted.

August 13, 1940: The pseudarthrosis was roentgenographically solid, but a new medullary canal had not been established.

December 27, 1940: The vitallium screws were removed under local anaesthesia. There were 15 degrees of valgus of the ankle. The affected leg was three-eighths of an inch longer than the normal. Roentgenograms showed bony union (Fig. 4-D).

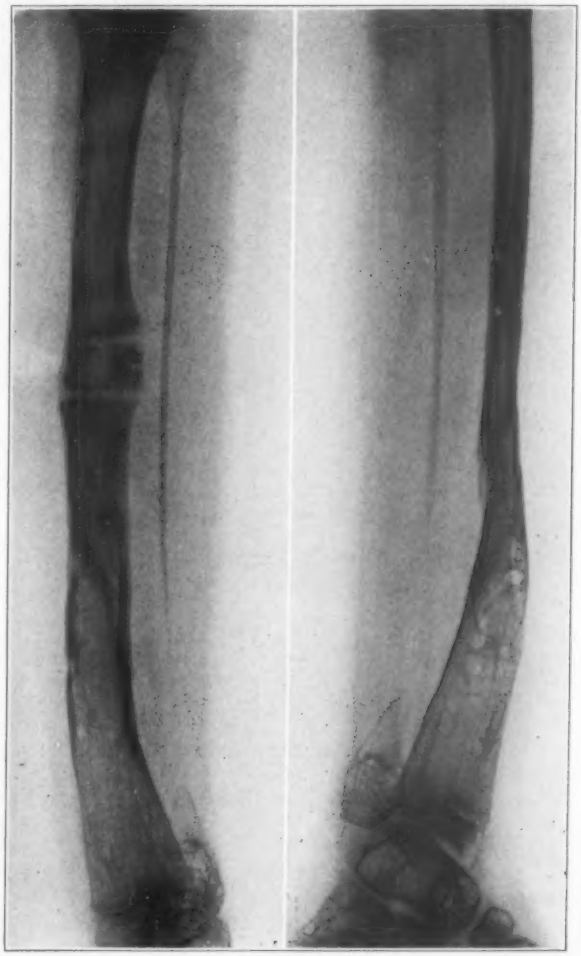

FIG. 4-D

FIG. 4-B: Case 3. Roentgenograms show dual bone graft immediately following the operation.

FIG. 4-C: Case 3. Roentgenograms taken six months postoperatively. Note the absorption of bone about the head of the proximal screw in the distal fragment. If this absorption occurred with a single graft, the result would probably be a failure. This screw was placed too close to the fracture site.

FIG. 4-D: Case 3. Roentgenograms taken seventeen months postoperatively. Screws were removed on this date. Bony union was present.

CASE 4. R. L. D., white male (Campbell Clinic No. 35657), was first seen on March 25, 1935, at the age of three. From the history it was learned that the lower extremities had been apparently normal at birth. As the child grew, his parents noted a gradual anterior and lateral bowing of the left tibia. With the increase in deformity, a limp gradually developed. On March 21, 1935, at the age of three, while walking, the patient turned his ankle and noticed immediate pain in the lower third of the leg. Following this, he refused to bear weight on the leg.

Roentgenograms re-

FIG. 5-A

FIG. 5-A: Case 4. Preoperative roentgenograms, showing pseudarthrosis of the left tibia. Roentgenograms taken prior to this date illustrate that the fracture occurred through a bone cyst.

FIG. 5-B: Case 4. Roentgenograms taken two months postoperatively, showing dual bone graft.

FIG. 5-C: Case 4. Roentgenograms taken seven months postoperatively. There is bony union at the fracture site.

vealed a fracture at the junction of the lower and middle thirds of the tibia, through a bone cyst.

March 26, 1935: A plaster-of-Paris cast was applied with the leg in as near normal position as possible without manipulation under an anaesthetic.

May 29, 1935: the cast was removed and a brace fitted.

November 16, 1936: A tenotomy of the tendo achillis was performed and the deformity partially corrected by manipulation. Skeletal traction was applied to correct the deformity gradually.

November 27, 1936: A long leg cast was applied.

May 13, 1937: The cast was removed, and a leather lacer brace applied.

September 20, 1939: The patient returned. He had not been wearing the brace. Pseudarthrosis persisted at the junction of the middle and lower thirds of the tibia. Angulation at the site of the fracture was 40 degrees (Fig. 5-A). The affected lower extremity was smaller and one-fourth of an inch shorter than the normal.

September 23, 1939: At the age of seven and one-half years, dual onlay bone grafts were applied, using tibial grafts from the mother. The blood grouping of the mother and patient were both Type II, and compatible.

November 15, 1939: Roentgenograms shows dual bone graft two months following the operation (Fig. 5-B).

January 26, 1940: Roentgenograms showed the beginning of bony union at the fracture site with union of the grafts to the tibia.

March 27, 1940: Cast immobilization was discontinued and a leather lacer brace applied.

April 17, 1940: Roentgenograms show solid bony union; however, a new medullary canal had not been completely established (Fig. 5-C).

July 5, 1940: Under local anaesthesia, the vitallium screws were removed.

September 18, 1940: Roentgenograms show solid bony union with reestablishment of medullary canal through the area of pseudarthrosis. The affected leg was one-half an inch longer than the unaffected leg (Fig. 5-D).

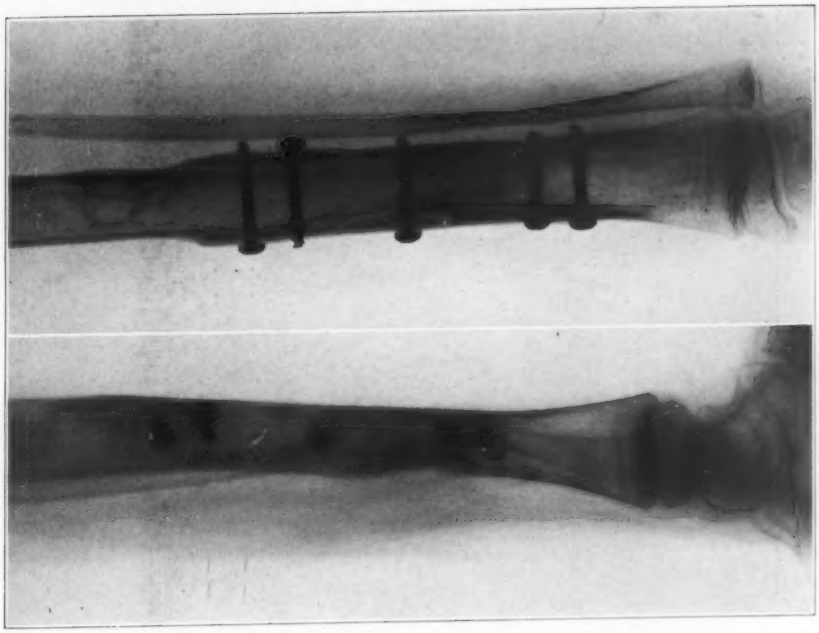

FIG. 5-C

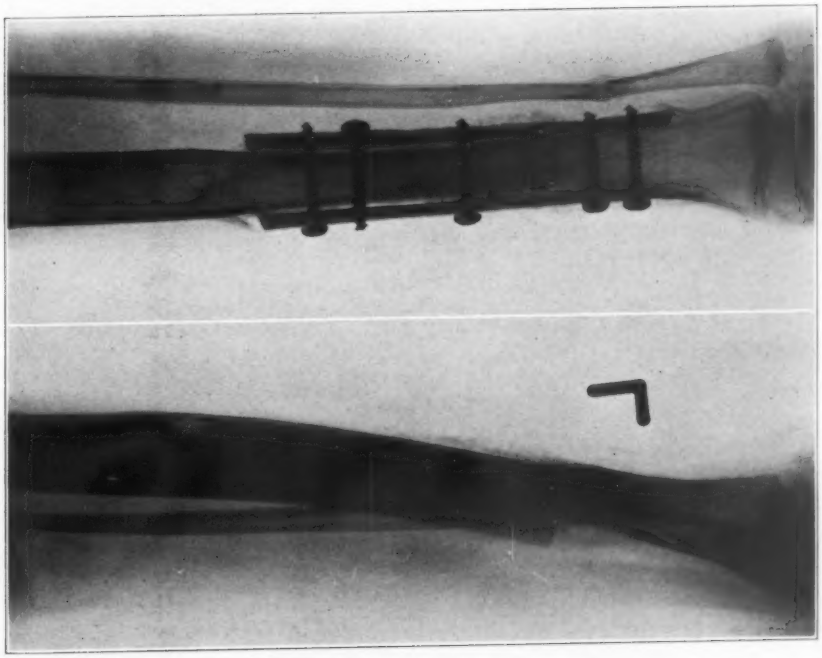

FIG. 5-B

FIG. 5-D

Case 4. Roentgenograms taken one year postoperatively. Solid bony union is present and a new medullary canal has been established across the fracture site.

RESULTS

In three patients with four single homogeneous grafts fixed by means of wire loops, one union was obtained (Case 1). Three consecutive patients in whom vitallium screws were used all have bony union. Dual grafts were used in the last two operated upon. One of these (Case 3) would probably have failed with a single graft as there was absorption about one screw head near the fracture site. These patients were operated upon fifteen years, twenty-one months, sixteen months, and fifteen months ago. One patient (Case 1) has a normal lower extremity for all practical purposes, and is not handicapped in any way. Three patients (Cases 2, 3, and 4) are walking in leather lacer braces at the present time.

It is too soon to report the final end result on the last three patients. From the present appearance of their roentgenograms, it is believed that all will ultimately have good weight-bearing extremities. The length of the affected lower extremities as compared with the sound side in the patients was as follows: Case 1, three-eighths of an inch shorter; Case 2, three-eighths of an inch shorter; Case 3, three-eighths of an inch longer; Case 4, one-half an inch longer. In the last three cases the leg lengths were checked with teleoroentgenograms. It is probable that the stripping of the periosteum near the epiphyseal lines to insert the dual grafts stimulated growth in Cases 3 and 4.

CONCLUSIONS

1. Bony union is more difficult to obtain in congenital pseudarthrosis than in any other type of non-union.
2. Union is more difficult to secure in younger than in older children.
3. If union can be obtained in childhood, the ultimate deformity and shortening of the leg are lessened or may be avoided.
4. The dual bone graft affords a sound mechanical procedure which should increase the percentage of bony unions in this condition.
5. The technique of the dual graft may also be used in the treatment of bony defects and in non-unions difficult to treat, resulting from causes other than congenital pseudarthrosis.

BIBLIOGRAPHY

BARBER, C. G.: Congenital Bowing and Pseudarthrosis of the Lower Leg. Manifestations of von Recklinghausen's Neurofibromatosis. Surg. Gynec. Obstet., LXIX, 618, 1939.

CAMURATI, MARIO: Le pseudoartrosi congenite della tibia. Chir. d. Org. di Movimento, XV, 1, 1930.

COLONNA, P. C.: Congenital Pseudarthrosis of the Leg. Three Cases Treated by Massive Bone Graft. J. Am. Med. Assn., CIII, 2012, 1934.

COMPERE, E. L.: Localized Osteitis Fibrosa in the New-Born and Congenital Pseudarthrosis. J. Bone and Joint Surg., XVIII, 513, Apr. 1936.

HALLOCK, HALFORD: The Use of Multiple Small Bone Transplants in the Treatment of Pseudarthrosis of the Tibia of Congenital Origin or Following Osteotomy for the Correction of Congenital Deformity. J. Bone and Joint Surg., XX, 648, July, 1938.

HENDERSON, M. S.: Congenital Pseudarthrosis of the Tibia. J. Bone and Joint Surg., X, 483, July 1928.

INGLIS, KEITH: The Pathology of Congenital Pseudarthrosis of the Tibia. J. Coll. Surgeons, Australasia, I, 194, 1928.

MCFARLAND, BRYAN: "Birth Fracture" of the Tibia. British J. Surg., XXVII, 706, 1939–1940.

MOORE, B. H.: Some Orthopaedic Relationships of Neurofibromatosis. J. Bone and Joint Surg., XXIII, 109, Jan., 1941.

SCOTT, C. R.: Congenital Pseudarthrosis of the Tibia. Am. J. Roentgenol., XLII, 104, 1939.

SMITH, A. DEF.: Use of Homologous Bone Grafts in Cases of Osteogenesis Imperfecta. Arch. Surg., XXXIV, 687, 1937.

WADE, R. B.: The So-Called Congenital Pseudarthrosis of the Tibia. J. Coll. Surgeons Australasia, I, 181, 1928.

THE USE OF SULFATHIAZOLE IN THE TREATMENT OF SUBACUTE AND CHRONIC OSTEOMYELITIS *

BY FRANK D. DICKSON, M.D., REX L. DIVELEY, M.D., AND RICHARD KIENE, M.D., KANSAS CITY, MISSOURI

This presentation is to be considered merely a preliminary report and in no sense as a finished investigation of the subject.

Hematogenous osteomyelitis is generally separated into three types, — acute, subacute, and chronic. This preliminary report deals primarily with the subacute and chronic forms, although two cases are included which might be considered acute.

Broadly speaking, in the past four types of procedure have been employed in the treatment of subacute and chronic osteomyelitis:

1. The conventional method of thorough débridement of the focus or foci, followed by repeated packing of the cavity with some form of material to provide drainage.

2. The maggot method of Baer in which, after thorough débridement of the focus, live maggots are introduced into the cavity. The maggots, acting as scavengers, remove all débris and produce a clean wound, which is allowed to heal by granulation, or is closed by secondary suture.

3. The Carrell-Dakin method, which consists in thorough débridement of the focus, followed by irrigation of the cavity with Dakin's solution every two hours, day and night, until the wound is free from infecting organisms, as demonstrated by laboratory methods. When the wound is sterile, secondary closure is made.

4. The Orr method in which, following thorough débridement, the cavity is packed with vaseline gauze and the region adequately immobilized in plaster and left undisturbed for long periods of time. This formula is followed until healing is complete.

It is not our intention to discuss the relative merits of these four methods of treatment, except to state that the first has been largely discarded by those who have had any considerable experience in the treatment of osteomyelitis. The Carrell-Dakin and Orr methods are those most generally followed today, with the Orr method decidedly leading in popular favor. Both the Carrell-Dakin and the Orr methods have definite disadvantages. The Carrell-Dakin method usually requires a long period of hospitalization and meticulous care in the daily dressings which are necessary. The chief objections to the Orr method, in the authors' opinion, are the long period required for healing, and the fact that healing is largely by scar tissue,—a real disadvantage in many locations. Recogniz-

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ing the disadvantages of the methods in use for the treatment of osteomyelitis, and having been impressed with the results reported by Key, Frankel, and Burford [1], following the implantation of sulfanilamide in contaminated wounds, the authors determined to try out sulfathiazole, administered by mouth and implanted in the wound, in the treatment of subacute and chronic osteomyelitis. Sulfathiazole was selected because it is a more effective agent than sulfanilamide against the staphylococcus, and so should be more effective in the treatment of osteomyelitis, in which staphylococcus is the infecting organism in 90 per cent. of the cases.

The plan of attack was based on the statement made by Key, Frankel, and Burford that powdered sulfanilamide in a wound is similar to a test-tube experiment in which a concentration of approximately 1,000 milligrams of the drug is brought into contact with any bacteria which may be present in the media. In such concentration, according to them, the sulfanilamide is effective against small numbers of staphylococci and of Welch bacilli, and against large numbers of streptococci. These authors, as the result of their work, concluded that when sulfanilamide is implanted in a wound, the drug exerts a neutralizing effect on the toxins present, thus minimizing the amount of tissue breakdown, and that the drug converts bacteria into a static or non-pathogenic phase in which they do not invade the surrounding tissues and do not multiply. In this static state, the bacteria are taken care of by the normal clearing mechanism of the animal and are destroyed. It was felt that if this premise was sound—and it seemed to be—a thorough débridement of the sinus and infected bone in subacute and chronic osteomyelitis, and the introduction of sulfathiazole powder into the wound should be effective in the same way against the comparatively small number of staphylococci and other contaminating organisms which would remain. An additional indication for the use of powdered sulfathiazole locally was the considerable evidence to show that pus is a definite depresser on the action of the sulfathiazole group, and that fibrous encapsulation of a focus makes it difficult for the drug to reach the focus through the blood stream in sufficient concentration to be effective. Both of these factors are present, to some extent, in subacute and chronic osteomyelitis; and consequently, the effect to be expected from sulfathiazole administered by mouth alone would be minimal.

The plan of treatment was: first, the administration of sulfathiazole for at least three days before operation in sufficient quantities to assure an average blood concentration of 4.7 per cent. (the purpose of this was to secure whatever benefit was possible from the presence of the drug in the blood stream); second, thorough débridement of the local focus and the introduction of powdered sulfathiazole into the wound. The local treatment was carried out as follows:

1. A tourniquet was applied to the extremity to be operated upon and kept in place until a cast was applied following the operation.

2. The sinus tract or tracts were injected with methylene blue for

the purpose of staining and so outlining all necrotic material in the soft parts and in the bone.

3. The sinus was completely dissected out down to the infected area in the bone.

4. The involved part of the bone was freely exposed and, using mallet, chisel, and gouge, all dead and necrotic bone, stained by the methylene blue, was removed, and the cavity saucerized as thoroughly as possible. The rough edges which remained were smoothed off by the use of an electric burr.

5. All scar tissue in the soft parts was dissected away as extensively as possible, thus providing healthy tissue which could be brought into contact with the bone cavity when closure was made.

6. One to two grams of sulfathiazole powder was then introduced into the wound, using a nasal insufflator.

7. The deep soft parts were then sutured with interrupted sutures in such a manner as to bring them into as close contact as possible with the denuded area of bone. Additional sulfathiazole powder was introduced into the wound and the superficial structures were closed with interrupted sutures. The skin was closed with cotton thread. A voluminous firm dressing was applied in such a manner as to press the soft parts firmly into the bone cavity. Finally, a plaster cast was applied, to adequately immobilize the extremity.

This treatment was first administered on August 1, 1940, since which time twenty-two osteomyelitic foci have been treated by this method. The following is a summary of the cases:

The number of hematogenous osteomyelitic foci treated was eighteen. The duration of the osteomyelitic process in the individual varied from nineteen years to thirty-seven days. The average duration was four and eight-tenths years. The duration of the activity in the particular focus treated also varied. The longest period of duration was two years, the shortest one week, and the average duration twenty-three weeks.

The drug was administered by mouth on an average of five and nine-tenths days before surgery and fifteen days after surgery. The average daily dose of the drug by mouth was 0.11 grams per kilogram or five grams per 100 pounds of body weight. The range of blood concentration during administration by mouth was from one to thirteen milligrams per 100 cubic centimeters. The average blood concentration on the day of operation was 4.7 per cent.

The results were as follows: Fourteen of the eighteen cases, or 78 per cent., healed by primary union; two, or 11 per cent., did not heal; and two, or 11 per cent., have been too recently treated to report. The average length of time from the day of operation to healing was twenty-one days. In many of these cases, approximately 50 per cent., there was some superficial breaking down of the skin incision, not in its entirety but at one or two points. These areas healed within one to two weeks in all cases.

The two unhealed cases are of interest. The first of these was an

osteomyelitis of the mandible, which apparently healed. Within a week following apparent healing, there developed a discharging sinus which, when probed, did not seem to lead down to bone, but which continued to discharge. The authors are unable to offer any explanation for this situation, since osteomyelitis of the mandible ordinarily heals rapidly. The second case was one in which the infection was due to the bacillus coli, determined before surgery was undertaken and at the time of operation. The inefficacy of sulfanilamide and sulfathiazole against bacillus coli is well recognized, and was certainly demonstrated in this case. The authors believe that a proved bacillus coli infection should not be treated by this method. This case is now being treated by the Carrell-Dakin method, and, as soon as the colon infection is cleared up, the wound will be closed by secondary sutures and powdered sulfanilamide or sulfathiazole introduced into the wound. In one acute case the wound was opened and drained for thirty-seven days, and then closed, using sulfathiazole powder. This wound closed by primary intention and has remained closed. A second case, which had some of the characteristics of an acute case, was of a boy whose original focus, in the lower end of the femur, had been healed for five months. The new focus was in the upper third of the femur, entirely separate from his original focus. When seen, the abscess had ruptured through the periosteum, and the thigh was distended with pus which had infiltrated between the muscle planes, forming many pockets. This case after débridement was treated by the Carrell-Dakin method for ten days. At the end of ten days, secondary closure was carried out, using sulfathiazole powder in the wound. This wound healed by primary intention in three weeks and has remained closed for two and a half months.

In addition to the eighteen osteomyelitic foci of hematogenous origin, four cases, in which the osteomyelitis followed a compound fracture, have been treated by this method. In these four cases, the longest period during which infection had been present was four years, the shortest was forty-one days, and the average was nineteen months. In all four cases healing was complete. The average length of time between surgery and healing was twenty-six days. The blood concentration of the sulfathiazole and the amount of powder used locally was the same as that in the cases of hematogenous osteomyelitis.

If the four cases of osteomyelitis following compound fracture are added to the eighteen cases of hematogenous osteomyelitis, the series reported includes twenty-two cases. Of the wounds in these twenty-two cases, eighteen, or 82 per cent., healed; two, or 9 per cent., failed to heal; and two, or 9 per cent., are too recent to report. The average length of time required for healing after operation in these twenty-two cases was twenty-three days.

CONCLUSIONS

1. A series of twenty-two foci of subacute and chronic osteomyelitis is reported in which the treatment employed was the administration of

sulfathiazole by mouth, thorough débridement of the focus, and the introduction of sulfathiazole powder into the wound. In 82 per cent. of the cases in this series, there was healing by primary intention with an average healing period of twenty-three days following surgery.

2. This is a comparatively small series of cases, and no attempt can be made from it to arrive at a final conclusion as to the value of the method proposed. However, the results have been sufficiently satisfactory, both in regard to the type of healing and the healing period, to suggest that the method should be given a thorough trial.

1. KEY, A. J.; FRANKEL, C. J.; AND BURFORD, T. H.: The Local Use of Sulfanilamide in Various Tissues. J. Bone and Joint Surg., XXII, 952, Oct. 1940.

A METHOD OF CORRECTING THE DEFORMITY IN SCOLIOSIS BEFORE PERFORMING THE FUSION OPERATION

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From the Hospital for Sick Children, Toronto

The most satisfactory method, at present available, of treating cases of scoliosis, particularly those cases where the deformity is already fairly marked and almost certain to become worse, is the method that has been developed over a period of years at the New York Orthopaedic Hospital.[1,2,3] There are three main principles that govern this method of treatment: first, to find out which is the primary curve; second, to make this primary curve as straight as possible; and finally, to stiffen this curve permanently in the straightened position by a fusion operation. All these principles are excellent.

The most difficult part of the whole treatment is the straightening of the primary curve. In most cases for which this method is used, the primary curve has become so stiff that it cannot be straightened completely. It can be improved a good deal, particularly towards its ends, by bending the spine in the opposite direction, but there is a limit to the amount of improvement that can be obtained. As far as the author has been able to find out by using different amounts of bending force and observing their effects by roentgenograms, increasing this force straightens the curve until a certain point is reached, when the correction stops rather suddenly. Any greater force will not produce any further correction of the primary curve, although it may increase the more flexible secondary curves. The Risser jacket, as used at the New York Orthopaedic Hospital, can, by its turnbuckle, be made to exert a great deal of force, but this great force is not necessary, and is sometimes dangerous. Once the limit of correction is reached, and there is no further yielding of the spine, strong pressure comes against the skin and, if the turnbuckling is continued beyond this point, a pressure sore will result. It is difficult to tell when the limit of correction has been reached and when the skin has been subjected to as much pressure as it will stand. In using the turnbuckle, one is apt to go too far and produce a sore or, from caution, to stop too soon and fail to obtain all the correction possible. Besides this difficulty in knowing how far to go with the turnbuckling, there are other objections to the Risser jacket. The whole method seems unreasonably complicated, requires a great deal of attention, and takes a fairly long time before the patient is ready for the fusion operation. Further, during the process of correction, the jacket is bent around one point, whereas the body bends at several levels. The shape of the jacket and that of the body change differently and, in the final position, the position in which the patient has to remain for a long time, the jacket does not fit, and may cause undue pressure on two or three points.

In an attempt to overcome these objections to the turnbuckle jacket, the author has, in the past two and a half years, been doing the correction in a different way. The patient is placed on his side in a net hammock, and the two ends of the hammock are slung up to the ceiling with the body bent rather sharply in a direction to correct the primary curve (Fig. 1). He is placed in the hammock for an increasing length of time each day until he becomes used to the bent position. While he is hanging in the hammock in this position, a plaster is applied which extends from the head to one foot (Figs. 3 and 4). A window is cut in the back of this plaster and the patient is ready for the fusion operation. No further alteration in the plaster is necessary, and the patient is kept in the same plaster in the same position until about three and a half months after the operation.

FIG. 1

Patient suspended in hammock, ready for application of plaster.

This method is no more efficient in correcting the primary curve than is the Risser jacket, but the author believes that it is just as efficient and that it has certain advantages. Several attempts have been made to obtain more correction of the stiff curves than can be obtained by the hammock alone, but without success. In one case the jacket, applied with the patient in the hammock, was converted into a hinged jacket, and bent further by a turnbuckle. Roentgenograms showed that none of this increased bending took place in the primary curve. The patient soon developed a pressure sore with the turnbuckling, and the method was therefore not tried again. It was thought that, by prolonged stretching of the shortened structures on the concave side of the curve, it might be possible to increase the amount of correction. Several patients were placed in

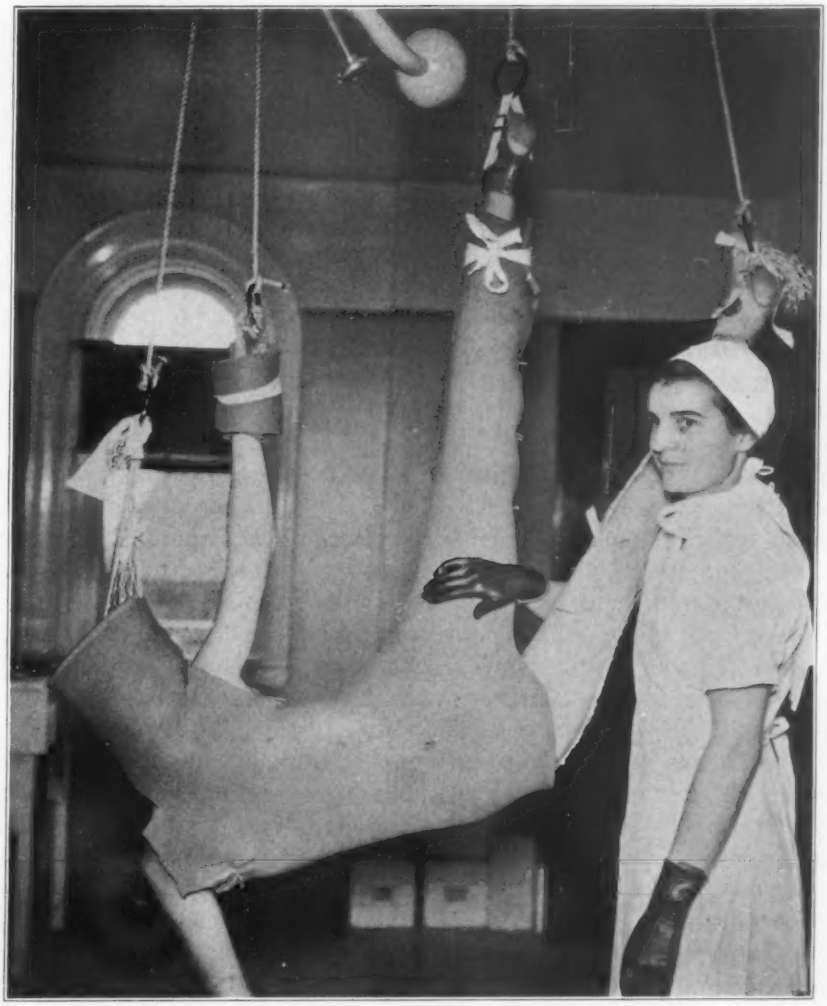

FIG. 2

Application of sponge-rubber padding.

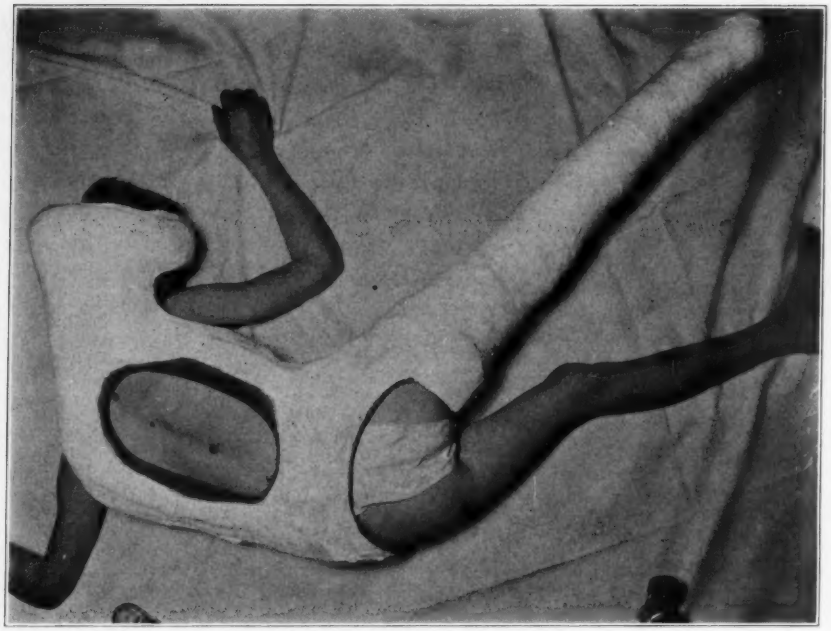

FIG. 3

Completed jacket from the back.

the hammock for as long as two hours a day for three or four weeks, but the roentgenograms taken in the hammock did not show any increase in the correction after the first few days. It was also thought that fixation for a while in the position of extreme correction might result in enough softening of the resistant structures to allow further correction. Two patients were put in plaster in the hammock, and in about three weeks' time the plaster was removed. After being placed in the hammock for two or three days more, another plaster was applied, with no further improvement in the primary curve.

The author is, therefore, convinced that the stiff primary curves can be corrected to a certain limit by a moderate amount of bending force, and cannot be corrected further by any reasonable force that the patient can stand. The amount of bending force required to correct the curve to its limit can be as well obtained in the hammock, as it can with the turnbuckle jacket, or with any other mechanical force applied externally.

This hammock method has certain advantages over the turnbuckle jacket. It is much simpler, and, aside from the supervision necessary during the preliminary daily suspension, requires very little attention. The application of the plaster, with the patient in the hammock, is easy, and, once the jacket is applied, it needs no further alteration. In the hammock, it is fairly easy to tell how much bending the patient will stand, and it is comparatively simple to adjust the position so that the maximum amount of correction is obtained, without undue discomfort, and without

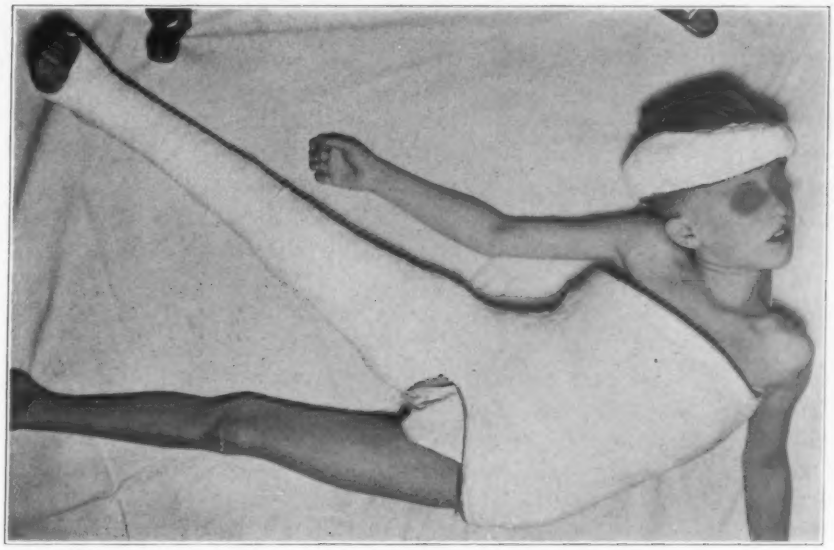

FIG. 4
Completed jacket from the front.

undue pressure of the plaster on the skin. The plaster is put on with the patient in the final position and should fit accurately during the whole time that it is on. It is comfortable and there has been no trouble with pressure sores. The jacket applied in this way is much less bulky than the turnbuckle jacket, which is a help when roentgenograms are taken and during the operation. The main advantage is that the method is quicker, and the amount of time taken to get the patient ready for operation is considerably shortened.

There are several details that have been learned about the use of the hammock. The net is the ordinary fish net, with about a one-inch mesh, and should be made of cord that has very little yield to it. The net stretches in length when the patient is placed in it, but there should be no further stretching once the application of the plaster is started. The strip of net should be long enough to extend well beyond the patient at either end, and should be about sixteen inches wide before the patient is put in it. If it is too wide, it is difficult to pull out from under the plaster, and, if it is too narrow, the patient may slip out of it. The hammock is suspended by its two ends over pulleys, which are so arranged that the distance between them can be altered. The whole suspending apparatus should be strong and, as a further precaution against accident, a stretcher should be kept under the patient when he is in the hammock. The bending of the patient is brought about by the force exerted chiefly on the head and on the lower of the two legs. The upper arm and upper leg are also suspended, but only enough pull is applied to these to keep the body from rotating. The lower arm hangs through a hole in the hammock, and may be allowed to rest on the stretcher beneath.

The position in which the patient is suspended, when the plaster is applied, is important. In the hammock, the bending takes place along the whole length of the spine, but mostly at the part of the spine that is lowest when the patient is in the hanging position. The point of maximum bending can be shifted toward the upper part of the spine by raising the leg end of the hammock, or shifted toward the lower part by raising the head end. The maximum bending should take place at, or slightly below, the apex of the primary curve, and the hammock should be so suspended that this part of the spine is the lowest part. To obtain the maximum correction of the curve, the two ends of the hammock should be as close together as the patient will stand without undue discomfort. When the patient is first put in the hammock, this bending is uncomfortable, and is resisted by the muscles. The first suspension should last for only a short time and should be done with the ends of the hammock fairly far apart. The patient soon gets used to the position, and the length of time is increased each day with the ends of the hammock brought closer together. It will be found that there is a definite limit to the amount of bending that each patient will stand, and there is no way of extending this limit. When the ends of the hammock are brought close enough together to cause marked discomfort, and when the tendency to rotate the body becomes uncontrollable, it means that too much force is being applied, and prolonged suspension in this position will not make it any more tolerable. The ends of the hammock are then separated slightly, until the patient is reasonably comfortable, and this position is accepted as the best position obtainable. Exactly the same position is maintained for any further use of the hammock that is necessary, and for the application of the plaster. Figure 1 shows the patient suspended in the hammock in the best possible position for a stiff curve with its apex at the seventh thoracic vertebra. The suspended ends of the hammock are as close together as the patient will stand, and the foot end is enough higher than the head end to bring the maximum bending force to about the level of the seventh thoracic vertebra. If the ends are any closer together, the patient will have a good deal of discomfort while in the hammock, and this discomfort will persist for some time in the plaster, without any improvement in the position. If the apex of the curve is at the ninth thoracic vertebra, the head end of the hammock should be relatively higher than shown in the photograph. If the foot end is much higher than shown, the cervical spine will be rather sharply bent, and the brachial plexus may be injured by stretching. The position of the spine obtained in the hammock can easily be shown by roentgenograms taken with a portable machine. As a rule, during the last two days roentgenograms have been taken with the patient in two slightly different positions, to determine which position is the best. It takes, on an average, about a week or ten days of being placed in the hammock, before the patient can stand it for a long enough time to have the plaster applied.

With the patient hanging in the hammock, the actual application of

FIG. 5-B

Preoperative roentgenogram of the patient in plaster, showing correction obtained in the hammock.

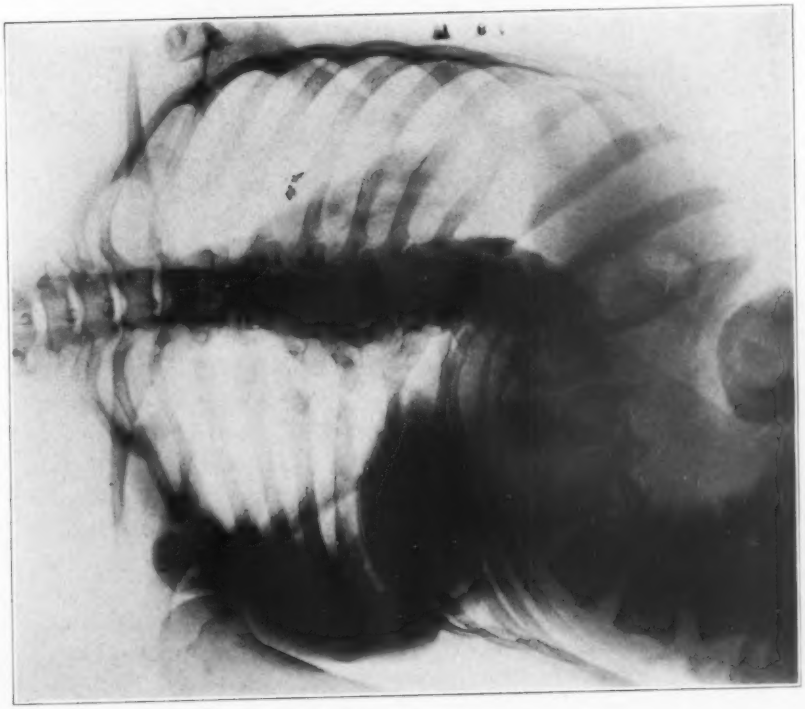

FIG. 5-A

Congenital scoliosis. Position before treatment, patient standing.

FIG. 6-A

Paralytic scoliosis. Position before treatment, patient standing.

the plaster is comparatively simple. If the net is to be pulled out afterwards, it should be placed next to the skin. The only padding used is a single layer of porous sponge rubber, about half an inch thick. This has proved to be very satisfactory and comfortable, and, even in hot weather, causes no trouble with the skin. It is obtained in sheets about three feet square, which are cut to fit the patient fairly accurately, and are held in place by a few stitches (Fig. 2). It is somewhat elastic, and adapts itself fairly well to the contour of the body in the bent position. When the plaster is completed, the rubber is turned over at every edge and fixed by a few stitches and by additional turns of plaster. Putting on the sponge-rubber padding adds somewhat to the time and trouble taken for the ap-

FIG. 6-B

Preoperative roentgenogram of the patient in plaster, showing correction obtained in the hammock.

plication of the jacket, but, as the patient has to lie in the jacket for three or four months, the additional comfort makes it worth while. The lower part of the plaster is applied in much the same manner as a hip spica, extending upward to just below the axillae. Several turns are then put around the head just above the ears, and this head piece is joined to the plaster over the back by a slab of plaster, wide enough to allow the upper part of the window to extend into it, and strong enough at its edges to keep from breaking. The leg that is high with the patient in the hammock—that is the one on the convex side of the original primary curve—is the one included in the plaster. In most cases the whole length of the leg and the foot are included. This is done because, with the plaster ending above

the knee, the pelvis sometimes tilted within the plaster, and some of the bending obtained in the lower part of the spine was lost. To prevent this downward tilting of the pelvis on this side, the plaster was extended to include the foot, and was applied with a moderate upward push on the sole. These patients usually sleep on their back, but prefer to spend most of the day on their side, with the leg in the air. The inclusion of the knee in plaster makes this position more comfortable. The plaster extending from the head to one foot is surprisingly comfortable and very efficient, and none of the bending obtained by the hammock is lost as long as the plaster is on.

The whole subject of the treatment of scoliosis by correction and fusion was very well described in the paper by Smith, Butte, and Ferguson. In that paper two points were mentioned which are not always followed, but which are important enough to emphasize. One is that if the primary curve cannot be completely straightened, the fusion should be extended upward and downward into the compensatory curves, until vertebrae are reached that are parallel and centered in the same line. If this is done, the fused part of the spine is made into a solid block of bone which may not be straight, but which has its top and bottom surfaces parallel and in line. This is much better than the more or less wedge-shaped block of bone produced if the fusion does not extend far enough. The other point is that the fused part of the spine should be protected against bending for a long enough time after the operation to allow the fusion to become solid. In the Hibbs operation [1], the available bone has always seemed insufficient in amount, and, for some years, the author has been adding to this bone by cutting several long thin sliver grafts from the tibia. These grafts are placed in the gutter, under the bone flaps raised from the sides of the spinous processes and backs of the laminae, and are so placed that they overlap each other. In children at any rate, this method produces a large column of bone that in time becomes solid, and the author thinks that, with it, a pseudarthrosis is less likely. When two fusion operations have to be done, the likeliest point for pseudarthrosis is the junction of the two. To avoid this, at the first operation the author has extended the fusion about two vertebrae farther on one side than on the other so that, finally, the junction of the two fusions will be at different levels on the two sides. No matter how the fusion is done, it will be a long time before it is solid, and the spine should be protected until it is solid. The original bent jacket, applied in the hammock, is removed three and a half months after the last fusion operation, and then a shorter and straighter jacket is applied, in which the patient is able to walk about. A jacket ending below the armpits provides practically no support to a curve of the usual level. To the jacket should be added a loop of plaster over the shoulder that keeps the neck bent slightly in the same direction as the original plaster. This straighter jacket should be kept on for a varying length of time, depending on how much bending strain there is. If there is a considerable amount of curve still present, and if there is much muscle paraly-

FIG. 7-B

Preoperative roentgenogram of the patient in plaster, showing correction obtained in the hammock.

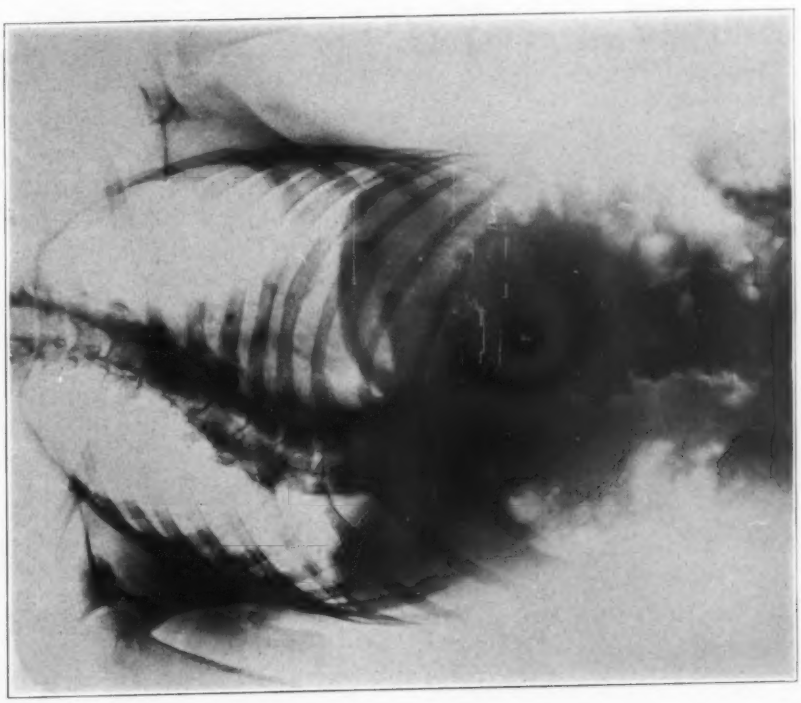

FIG. 7-A

Idiopathic scoliosis. Position before treatment, patient sitting.

sis, the support should be continued for a long time, sometimes as long as a year and a half. If the curve has been completely straightened, and there is no muscle paralysis, the jacket is continued for at least seven months after the last fusion operation.

The only thing really new offered in this paper is the use of the hammock for the correction of the curve, and for the holding of the patient while the plaster jacket is being applied. This method has been used in twenty-seven cases and has been found to be considerably more satisfactory than the turnbuckle jacket.

REFERENCES

1. Hibbs, R. A.: A Report of Fifty-Nine Cases of Scoliosis Treated by the Fusion Operation. J. Bone and Joint Surg., VI, 3, Jan. 1924.
2. Hibbs, R. A.; Risser, J. C.; and Ferguson, A. B.: Scoliosis Treated by the Fusion Operation. An End-Result Study of Three Hundred and Sixty Cases. J. Bone and Joint Surg., XIII, 91, Jan. 1931.
3. Smith, A. DeF.; Butte, F. L.; and Ferguson, A. B.: Treatment of Scoliosis by the Wedging Jacket and Spine Fusion. A Review of 265 Cases. J. Bone and Joint Surg., XX, 825, Oct. 1938.

FRACTURE-DISLOCATIONS OF THE HIP JOINT

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HISTORY

Before the advent of the automobile and the roentgen ray, dislocations of the hip associated with fractures of the acetabular lip held a fascination for the surgeon largely because of their rarity. Diagnosis could be established with certainty only by postmortem examination, and consequently the lesion was rarely recognized.

The first authentic cases of fracture-dislocation of the hip, which were verified by autopsy examination, were reported by Sir Astley Cooper in 1805. Malgaigne, in 1850, reviewed the twelve cases which had been previously reported, and postulated that the condition should be suspected if crepitation could be felt on manipulating the dislocated hip, or if the head tended to redislocate readily after its initial reduction. Thirty years later, in 1880, Senn, in a report based on twenty-seven clinical cases and experimental work on the cadaver, concluded that extreme violence was necessary to fracture the acetabular rim. Crile, in 1891, reported the first case of a dislocation of the hip joint, with fracture not only of the acetabular lip, but also of a portion of the head of the femur. Since the advent of roentgenography, fracture-dislocations of the hip have been reported with increasing frequency, notably by Stimson, Hamilton, Gatewood, Wheeler, Lenormant, Koven, Henderson, and more recently by Cubbins, Conley, and Callahan, and by Grinda.

In 1927 Breton and Blondeau pointed to the increasing frequency of this lesion in automobile accidents, and gave it the name "automobile injury" of the hip joint. Nine years later Campbell reported eighty cases of posterior dislocation of the hip, thirty, or 37.5 per cent., of which were the typical fracture-dislocations with which the authors are concerned in this paper.

In 1938 Funsten, Kinser, and Frankel reviewed twenty cases of dislocation of the hip, which they had followed for at least three years. Thirteen of these were due to automobile accidents, and in nine cases the acetabular rim was fractured. The results were good in eleven cases; aseptic necrosis of the femoral head developed in six patients, three of whom had to be operated upon later. These authors concluded that immediate reduction with traction gives good results; and that the longer the dislocation persists before reduction, the poorer the prognosis.

The clinical studies of Dyes, Stewart, Phemister, Obwegeser, Pfab, Kleinberg, and Potts and Obletz have demonstrated that the most

frequent complications of this lesion are traumatic arthritis and aseptic necrosis of the femoral head. Myositis ossificans and injury to the sciatic nerve occasionally occur.

FIG. 1-A

FIG. 1-B

Fig. 1-A: Experimental fracture-dislocation of the hip in a dog.
Fig. 1-B: Twenty-two weeks later there is marked restriction of movement.
Fig. 1-C: Experimental fracture-dislocation of the hip after twenty-two weeks. There is a large amount of new bone around the acetabulum, and marked generalized fibrosis. The head is riding in a new acetabulum posterosuperiorly, and is covered with fibrous tissue except in one small area anteriorly, where it is eburnated and polished.

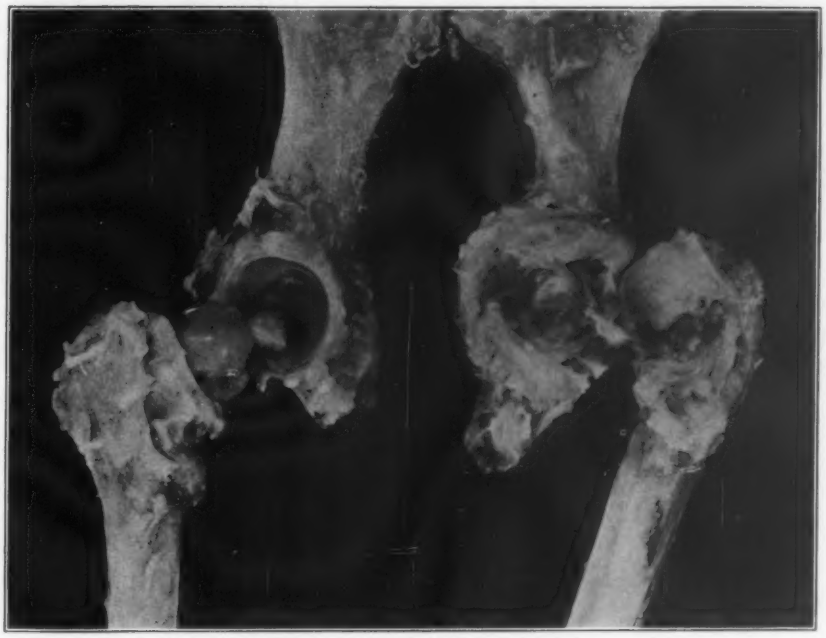

FIG. 1-C

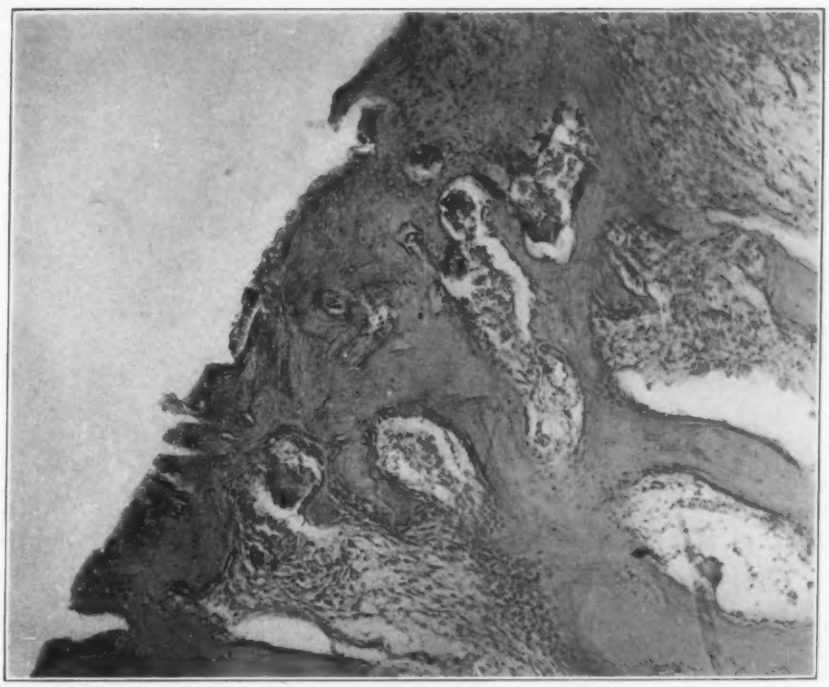

FIG. 1-D

Section through the head shows complete disappearance of articular cartilage, thickening of the cortex, and fibrosis of the marrow spaces.

FIG. 2-A

Experimental fracture-dislocation in the hip of a dog.

MECHANISM

In a few cases this injury has resulted from a fall on the flexed knee, usually from a height. In the majority of cases, however, the injury has been received in an automobile accident. Characteristically the patient is seated with knee and hip flexed to 90 degrees, and is thrown suddenly forward, so that the knee strikes against the instrument panel.

The tremendous force with which a person may be thrown against the instrument panel (or against the back of the front seat if he is riding in the rear seat) is well illustrated as follows: The kinetic energy of a 150-pound body moving forty-five miles per hour is 10,200 foot pounds.* In bringing this moving body to rest, the same amount of energy must be expended (10,200 foot pounds is equivalent to five tons falling one foot).

That an enormous force is required to produce the lesion is also suggested by the inability of various workers to produce it experimentally by direct blows on the flexed knee of the cadaver. Senn, in 1882, had one success in seven experiments, Allis in 1896, Virevaux in 1899, Fox and Schroeder in 1909, and King † in 1938 were unsuccessful.

The force of the blow may be spent in disrupting the knee joint, fracturing the femoral shaft, or driving the femoral head out of, or through the posterior wall of the acetabulum. As the head is driven out of the

* Calculations by Mr. Hackney:

$$\frac{1}{2} \times \frac{W}{32} \times v^2 = \frac{150}{32} \times (66)^2 = 10{,}209$$

This figure is for a sudden complete arrestment of movement. In an automobile accident there are, of course, many variables,—such as speed of motion, weight of the patient, friction against the seat, distance in which the car motion is stopped, resistance of object struck, etc.

† Experimental work unpublished.

acetabulum into a posteriorly dislocated position, a variety of fractures may result. The three common ones are:

1. Posterior lip fracture.
2. Sprain fracture of the femoral head (a small fragment of the head attached to the round ligament remains in the acetabulum).
3. A transverse fracture across the floor of the acetabulum.

FIG. 2-B

Roentgenogram shows result sixteen weeks later.

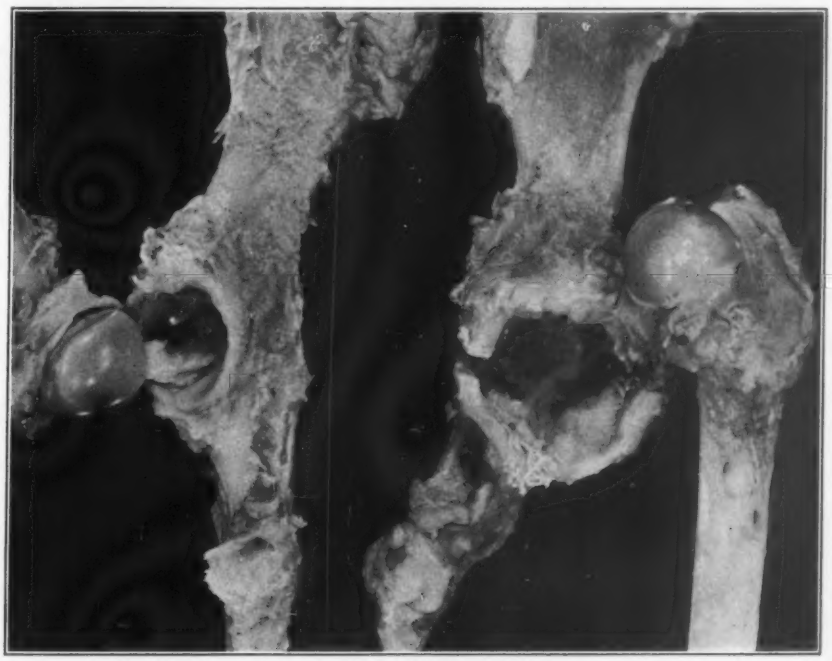

FIG. 2-C

There is marked degenerative arthritis. The head is in a false acetabulum, and there is no cartilage on the head which is markedly eburnated and polished.

The importance of correcting the slightest incongruity of articular surfaces resulting from joint fractures has been recognized and repeatedly emphasized for many years. This is particularly important in fractures into the joints of the lower extremity where weight-bearing

FIG. 3-A

FIG. 3-B

Fig. 3-A: Case 1. Posterior dislocation of the left hip with a large fragment of acetabular lip.

Fig. 3-B: The dislocation of the head is satisfactorily reduced, but the lip fragment is not in position. Note that its articular surface lies about a centimeter above the arc of the main body of the articular surface.

FIG. 3-C

FIG. 3-D

Fig. 3-C: Posterior view one year later. The loss of joint space is apparent, due to recurrence of the subluxation. The hip is painful and stiff.

Fig. 3-D: Roentgenogram shows the result after fusion.

Comment: The large acetabular lip fragment was not satisfactorily replaced, and reduction was unstable. On weight-bearing gradual subluxation occurred, with disintegration of the joint necessitating fusion.

Operative Findings: There were posterior subluxation of the head, fibrous union of the lip fragment in poor position, and loss of the articular cartilage from the head with much fibrous tissue in the acetabulum. No attempt was made to reduce the head completely into the acetabulum. It was fused with a Smith-Petersen nail.

FIG. 4-A

Case 2. Posterior dislocation of the left hip with lip fragment, and sprain fracture of the head.

FIG. 4-B

Posterior view of the reduction accepted by attending surgeon as satisfactory.

FIG. 4-C

Result three years later. The hip was stiff and painful, necessitating fusion.

Comment: Reduction was poor. The inferior surface of the head was not snugly in the floor of the acetabulum, due to imperfect reduction of the head fragment. The acetabular lip fragment was not replaced. Recurrence of subluxation on weight-bearing was followed by disintegration of the joint.

makes them especially prone to the development of degenerative arthritic changes.

The rapid disintegration which occurs in a hip joint following incomplete reduction of a fracture-dislocation is demonstrated by a series of eight such lesions experimentally produced in dogs. In each case a severe

FIG. 5-A

Case 3. Reduction accepted as satisfactory by attending surgeon.

FIG. 5-B

Case 3. Six months later there was complete subluxation.

FIG. 5-C

Case 3. Five years later the hip was stiff and painful.

FIG. 5-D

Case 3. Roentgenogram shows the result after fusion.

Comment: Posterior dislocation and sprain fracture of the head, with a large acetabular lip fragment which was not replaced.

Operative Findings: Complete posterior dislocation was found. The acetabulum was open posteriorly; the lip fragment was united to the ilium above the acetabulum; and there was complete disintegration of the joint. The head was fused to the ilium in subluxated position.

degree of degenerative arthritis developed within a few weeks' time. (See Figs. 1-A, 1-B, 1-C, 1-D, 2-A, 2-B, and 2-C.) This same degenerative reaction has been observed in a number of patients, due to either incomplete reduction, or gradual redislocation on weight-bearing. Roentgenograms of three illustrative cases are shown (Cases 1, 2, and 3).

It is not the authors' purpose to deal at great length with the treatment of the average case of fracture-dislocation of the hip. In brief, they believe that many cases can be reduced by manipulation, and that the lip fragment will come down with the head, falling naturally into its normal

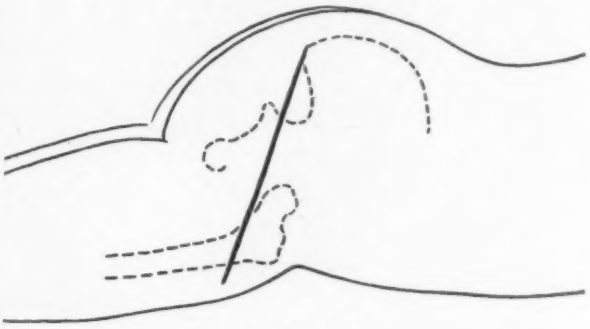

FIG. 6-A

Patient is placed prone upon the table, and the incision is made from the posterior superior iliac spine to the base of the trochanter of the right hip.

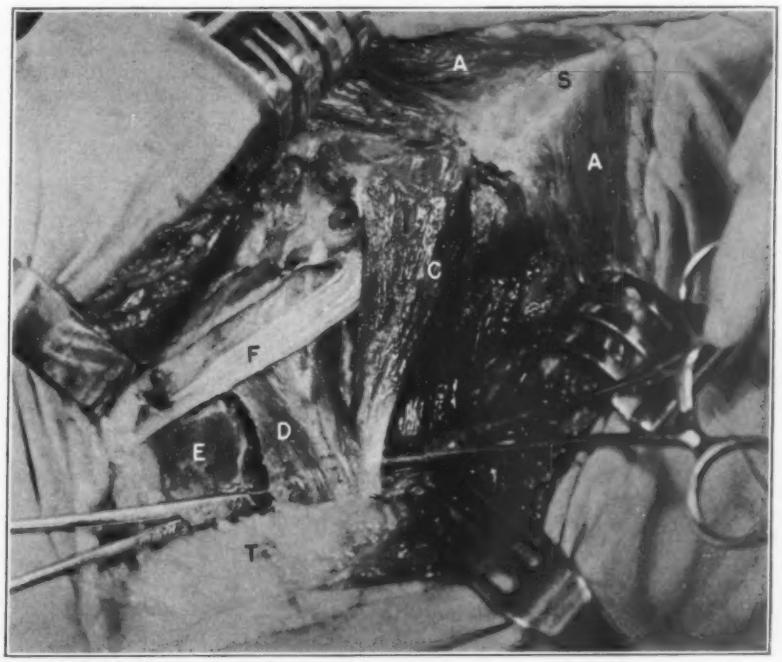

FIG. 6-B

Gluteus maximus muscle is split and retracted (*A*, *A*).

Hemostats are placed under the common tendon of the piriformis (*C*) and obturator internus and gemelli (*D*).

S = Posterior superior iliac spine; *F* = Sciatic nerve; *E* = Quadratus femoris muscle; *T* = Trochanter.

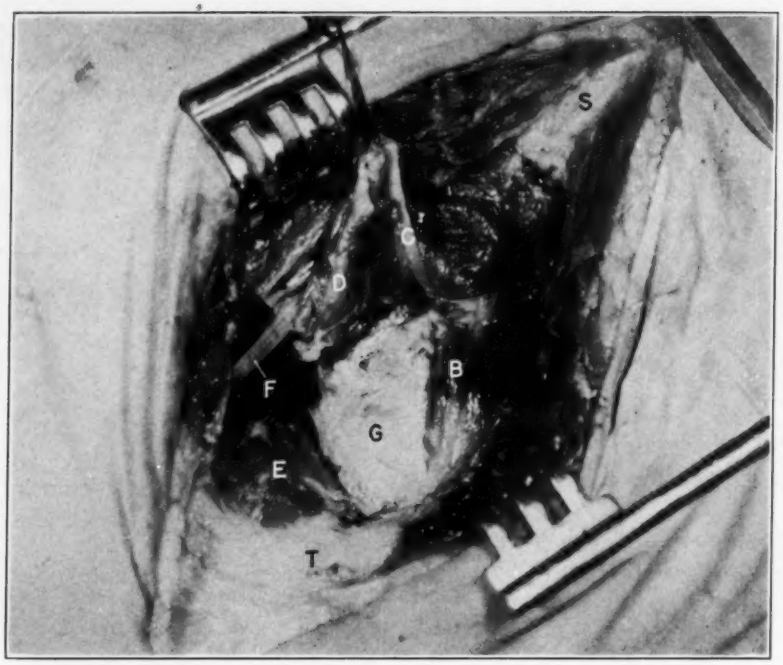

FIG. 6-C

The tendon of the piriformis, obturator, and gemelli is divided, and the muscle bellies (*C* and *D*) are retracted medially, exposing the posterior wall of the acetabulum (*G*). The sciatic nerve (*F*) is protected at its exit from the notch by the muscle bellies.

B = Gluteus minimus; *E* = Quadratus femoris; *T* = Trochanter.

position as the head reenters the acetabulum. If the lip fragment is small and narrow, it probably does not matter whether it comes completely down or not, as little if any of the articular surface is involved. Hip-spica immobilization in abduction and external rotation for eight to ten weeks, with two more weeks in bed for exercises, will be adequate for strong osseous union.

However, in many instances inadequate reduction of the head, of the lip fragment, or both, has been allowed to persist, thus establishing a perfect set-up for the development of degenerative arthritis. This may be due to failure to recognize in the postmanipulative roentgenogram, a small persistent subluxation, or unfamiliarity with the surgical technique of open reduction.

In this group there are many patients in whom, by operation, perfect anatomical reposition can be established. The technique for this procedure has been described accurately in the literature only once, by Griswold and Herd in 1929. Osborne, in 1930, described a posterior approach to the retrocotyloid region, but never utilized it.

The authors wish, therefore, to describe the technique which in their experience has been the simplest, surest, and safest for this acetabular redintegration.

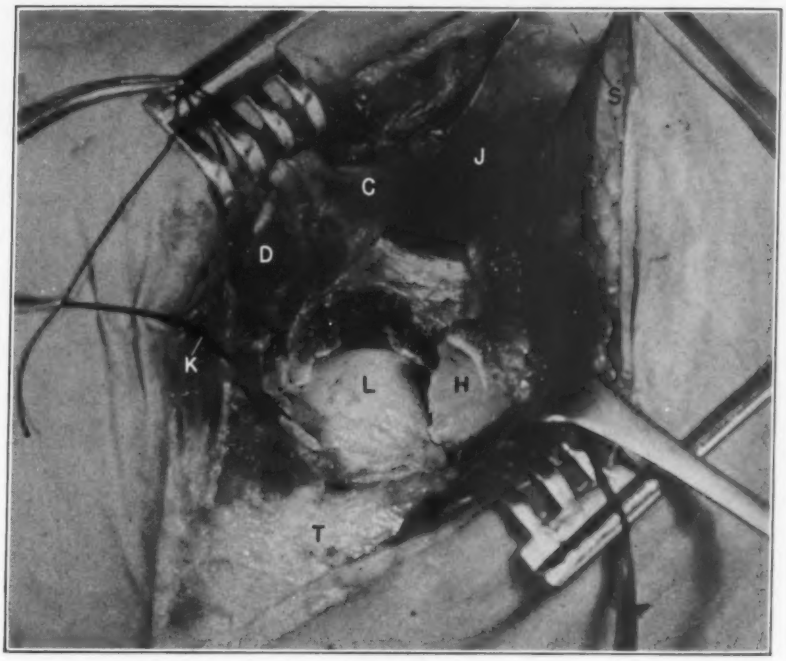

FIG. 6-D

Ribbon retractor (*J*) is placed in the pelvis against the intrapelvic surface of the acetabular floor. The posterior lip fragment (*H*) is in its characteristic position.

L = Head of the femur; *K* = Silk thread placed through the capsule.

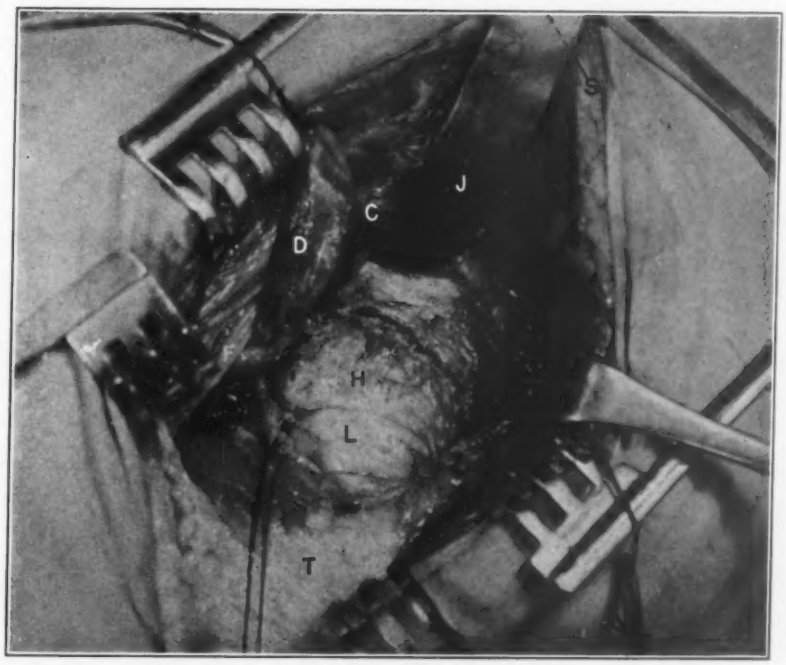

FIG. 6-E

Lip fragment (*H*) is replaced.

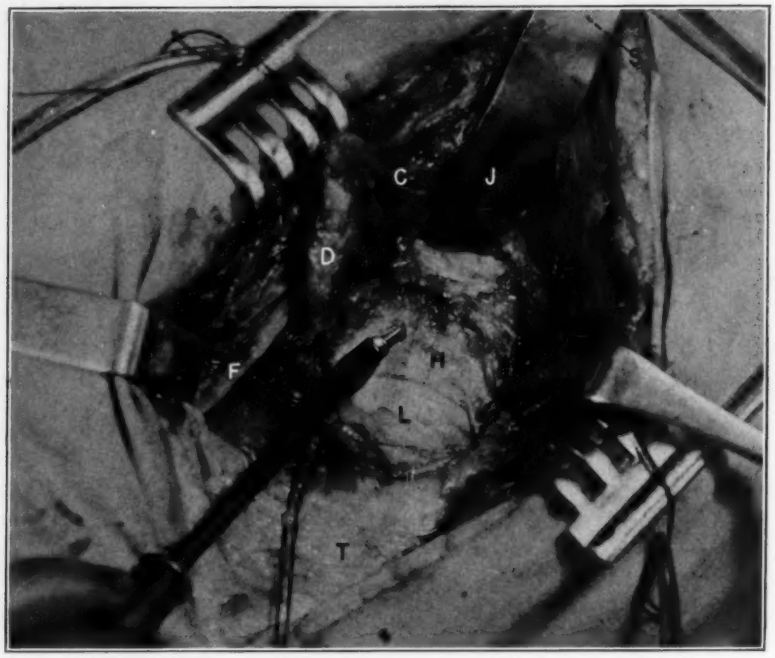

FIG. 6-F

Screw being inserted obliquely through the fracture line.

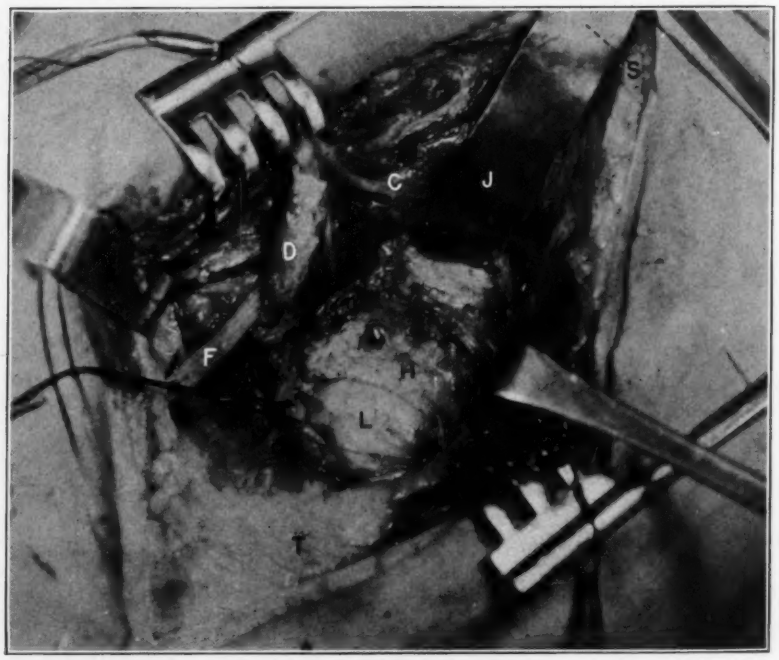

FIG. 6-G

In final position, screw is tight, and fracture line is obliterated.

THE OPERATIVE TECHNIQUE

The patient is placed prone and close to the edge of the table so that the extremity can be flexed over it if desired. The incision (Fig. 6-A) extends from the posterior superior iliac spine outward and downward to the base of the greater trochanter, and is deepened to the fibers of the gluteus maximus muscle. At its outer end the aponeurosis of this muscle is exposed and divided, thus opening the peritrochanteric bursa. A finger can now be placed inward and upward under the gluteus maximus muscle, which is divided the full length of the incision (Fig. 6-B). Very little bleeding is encountered, as the branches of the superior gluteal artery are contained in the superior half of the muscle and the inferior gluteal tributaries are in the inferior half. The two halves of the gluteus maximus muscle are retracted from each other. This gives a complete exposure of the sciatic nerve, the gluteus medius, piriformis, obturator internus, gemelli, and the superior border of the quadratus femoris muscles. The interval between the superior border of the piriformis and the inferior border of the gluteus medius is located, and the tip of a curved hemostat inserted from above downward under the common tendon of the piriformis, obturator internus, and gemelli. Another hemostat is inserted under this tendon from below, passing between the superior border of the quadratus femoris and the inferior border of the gemelli (Fig. 6-B). The tendon is now divided (Fig. 6-C), and, by retracting the muscle bellies medialward, an excellent exposure of the posterior wall of the acetabulum is secured. The trunk of the sciatic nerve is well protected by these muscle bellies which fold over it much as a closed book enfolds a book mark. A long, narrow, ribbon retractor is placed in the pelvis between

FIG. 7-A

Case 4. After manipulation the head is in satisfactory position in the acetabulum, but the lip fragment is not replaced. On allowing the extremity to approach a neutral position, the head dropped out of the acetabulum.

FIG. 7-B

Three years after fixation of the lip fragment with a beef-bone screw.

FIG. 8-A

Case 5. Posterior dislocation of right hip with lip fragment in acetabulum.

FIG. 8-B

After manipulation the head is opposite, but not in the acetabulum.

FIG. 8-C

Posterior view five years after operative removal of the fragment and reduction of the dislocation; function was normal.

the greater sciatic notch and the ischial spine, and against the intrapelvic surface of the acetabular floor (Fig. 6-D). Further exposure, if needed, is easily secured by subperiosteal elevation of the gluteus minimus superiorly.

From this point the operative technique will naturally depend on the pathology present. In the average case the dislocation has already been reduced, and it is only necessary to derotate the lip fragment (Fig. 6-E), place it in perfect anatomical position, and affix it with Matthews wires, nails, beef-bone, or vitallium screw (Fig. 6-F). Due to the thickness of the ilium at this point, there is plenty of bone in which the screw can get a good purchase. The screw must be placed at an oblique angle upward, however (roughly toward the middle of the iliac crest), so as to avoid penetrating the articular cartilage.

Postoperatively traction, hip spica cast, or Wilkie boots have been used. Active exercise is allowed in from eight to ten weeks, depending somewhat on the size of the lip fragment. In those cases with accompanying sprain fracture of the head, full immobilization is maintained for at least eight weeks. Weight-bearing is permitted in from ten to twelve weeks.

INDICATIONS FOR OPEN REDUCTION

Indications for open reduction are illustrated by the following cases:

1. Large lip fragment remains displaced after manipulative reduction of femoral head (unstable reduction).

CASE 4 (Figs. 7-A and 7-B). A. de C., aged forty-five, was injured in an auto accident. The hip was easily reduced, but the head remained in the acetabulum only when abducted

FIG. 9-A

FIG. 9-B

Case 6. Roentgenogram and diagram of roentgenogram show posterior dislocation, lip fragment, and sprain fracture of the head.

FIG. 9-C

After manipulation head was not properly placed in the depth of the acetabulum, and the lip fragment was not replaced.

FIG. 9-D

Fig. 9-D: Postoperative roentgenogram taken following excision of the head fragment, and reduction and fixation of the lip fragment with vitallium screw.

FIG. 10-A

Case 7. Roentgenogram of the left hip taken after manipulation shows the head in the acetabulum, fracture through the floor of the acetabulum, and large lip fragment not replaced.

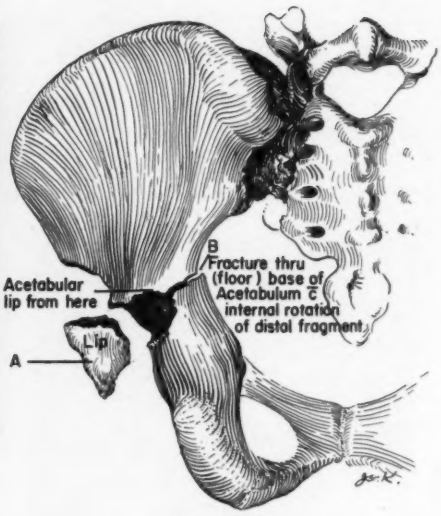

FIG. 10-B

Condition disclosed at operation (posterior view). *A:* Lip fragment; *B:* Fracture through the floor of the acetabulum. Note internal-rotation displacement of the distal fragment.

FIG. 10-C

Roentgenogram shows the postoperative result.

45 degrees and externally rotated. When the thigh was allowed to come to a neutral position the head dropped out of the acetabulum. A large fragment of the posterior lip remained displaced. At operation the lip fragment was found to be much larger than the roentgenogram would indicate, consisting of over one-half of the posterior lip. Without operative reduction of this fragment, progressive subluxation would surely have occurred on weight-bearing, followed by arthritic disintegration.

2. The lip fragment is in the acetabulum.

CASE 5 (Figs. 8-A, 8-B, and 8-C). L. W., aged twenty-six, was injured in an auto accident. The hip was manipulated, but reduction of the dislocation was impossible because the lip fragment was displaced into the acetabulum. At operation the fragment was found to be a very thin edge of acetabular lip. Reduction was completely stable, and the fragment was removed.

3. Sprain fracture of head prevents reduction.

CASE 6 (Figs. 9-A, 9-B, 9-C, and 9-D). C. W., aged forty-five, was injured in an auto accident. Repeated manipulations failed to place the head snugly in the acetabulum. Preoperative roentgenograms disclosed, in addition to the lip fragment, a sizable fragment deep in the acetabulum, obviously attached to the round ligament, and a corresponding defect in the inferior surface of the head of the femur. At operation the head was redislocated from the acetabulum. The mass of cancellous bone attached to the

round ligament was obviously not fitting snugly into its bed in the femoral head. It was removed, and no further difficulty was encountered in reducing the head and lip fragment.

4. Fracture through the floor of the acetabulum allows rotation of distal half of innominate bone, preventing reduction.

CASE 7 (Figs. 10-A, 10-B, and 10-C). G. W. was injured in an auto accident, and had a posterior dislocation, posterior lip fracture, and transverse fracture through the floor of the acetabulum. The posterior lip fragment remained high. At operation it was found that the lip fragment would not fit accurately into the defect.

The head was redislocated, and, with the extremity externally rotated and adducted, and the posterior acetabular lip out of the way, a perfect view of the entire acetabulum was obtained. It was then obvious that the distal fragment had rotated inward about two millimeters, making a definite "jog" in the articular surface which prevented anatomical reduction of the head and lip fragment. The tip of a screw driver was inserted into the fracture line, and by prying, the superior end of the distal fragment snapped into position. The femoral head was reduced, anatomical reposition of the lip fragment secured, and fixation accomplished by using two vitallium screws, one passing through the lip fragment into the superior fragment of the innominate bone, and the other through the lip fragment into the distal fragment of the innominate bone.

(In a second case in which this happened, reduction of the inward rotation of the distal half of the innominate bone was secured without redislocating the femoral head. In neither of these cases was the displacement of the distal fragment visible in the roentgenograms.)

5. An associated fracture of the femoral shaft prevents control of the head.

One case has been treated and two others have been observed, in which there was a fracture of the femoral shaft, accompanying the fracture-dislocation of the hip. In two of these cases satisfactory reduction was accomplished by the insertion of a Steinmann pin through the trochanteric region. In the third case satisfactory control of the proximal fragment was secured through the use of the pin, but operation was necessary because the lip fragment was displaced into the acetabulum.

SUMMARY

A review of the literature shows that posterior dislocation of the hip with associated fracture of the acetabular lip is comparatively uncommon.

It is characteristically an "automobile injury" and hence is increasing in frequency.

Without perfect reduction, arthritic disintegration of the joint occurs rapidly, due to mechanical incongruity of joint surfaces.

Roentgenograms of good quality must be studied with great care before the "reduction" is accepted.

Open reduction is indicated when:

1. The lip fragment is large and does not come down into position when the head is reduced (unstable reduction).
2. The lip fragment is in the acetabulum.
3. Sprain fracture of the head prevents perfect reduction.

4. A fracture through the acetabular floor allows rotation of the distal fragment which prevents reduction.

5. Femoral shaft fracture prevents control of the head.

The author has obtained satisfactory reduction by this operation.

REFERENCES

ALLIS, O. H.: An Inquiry into the Difficulties Encountered in the Reduction of Dislocations of the Hip. Philadelphia, Dorman, 1896.

BRETON, M., ET BLONDEAU, A.: Une variété de luxation de la hanche avec fracture du sourcil cotyloïdien, observée après certains accidents d'automobile. J. de Radiol. et d'Électrol., XI, 430, 1927.

CAMPBELL, W. C.: Posterior Dislocation of the Hip with Fracture of the Acetabulum. J. Bone and Joint Surg., XVIII, 842, Oct. 1936.

COOPER, A. P.: A Treatise on Dislocations and on Fractures of the Joints. Ed. 2. Philadelphia, Lea & Blanchard, 1844.

CRILE, G. W.: Report of Three Cases of Fractures with Fatal Termination. Case 1.—Fracture of the Base of the Skull; Multiple Fracture of Ribs; Fracture of Acetabulum; Fracture of Head of Femur. Ann. Surg., XIII, 373, 1891.

CUBBINS, W. R.; CONLEY, A. H.; AND CALLAHAN, J. J.: Fractures of the Acetabulum. Surg. Gynec. Obstet., LI, 387, 1930.

DYES, OTTO: Hüftkopfnekrosen nach traumatischer Hüftgelenksluxation. Arch. f. klin. Chir., CLXXII, 339, 1932.

FUNSTEN, R. V.; KINSER, PRENTICE; AND FRANKEL, C. J.: Dashboard Dislocation of the Hip. A Report of Twenty Cases of Traumatic Dislocation. J. Bone and Joint Surg., XX, 124, Jan. 1938.

GANDY, M.: Fracture transcotyloïdienne du bassin avec pénétration intra-pelvienne de la tête fémorale. Reduction aisée par extension continue sur broche de Kirschner. Mém. Acad. de Chir., LXIV, 1104, 1938.

GATEWOOD: Dislocation of the Hip with Fracture of the Acetabulum. Surg. Clin. Chicago, IV, 77, 1920.

GRINDA, J.-P.: Traitement des fractures de la cavité cotyloïde. Rev. d'Orthop., XXVI, 289, 1939.

GRISWOLD, R. A., AND HERD, C. R.: Dislocation of Hip with Fracture of Posterior Rim of Acetabulum. J. Indiana Med. Assn., XXII, 150, 1929.

HAMILTON, F. H.: A Practical Treatise on Fractures and Dislocations. Ed. 7. pp. 346–350. Philadelphia, Lea's Son & Co., 1884.

HENDERSON, M. S.: Old Traumatic Dislocation of the Left Hip. Surg. Clin. North America, X, 33, 1930.

KLEINBERG, SAMUEL: Aseptic Necrosis of the Femoral Head Following Traumatic Dislocation. Arch. Surg., XXXIX, 637, 1939.

KOVEN, BENJAMIN: Fracture of the Rim of the Acetabulum. Am. J. Surg., II, 267, 1927.

LENORMANT, CH.: Fractures de la cavité cotyloïde. Presse Méd., XXXVI, 788, 1928.

MALGAIGNE, J. F.: Traité des fractures et des luxations. p. 877. Paris, J.-B. Baillière, 1847–1855.

OBWEGESER, OSKAR: Über traumatische Hüftverrenkungen. Med. Klin., XXXII, 834, 1936.

OSBORNE, R. P.: The Approach to the Hip Joint: A Critical Review and a Suggested New Route. British J. Surg., XVIII, 49, 1930.

PFAB, BRUNO: Endausgänge von traumatischen Hüftgelenksverrenkungen. Arch. f. Ortop. u. Unfall-Chir., XXXIX, 135, 1938–1939.

PHEMISTER, D. B.: Fractures of Neck of Femur, Dislocations of Hip, and Obscure Vascular Disturbances Producing Aseptic Necrosis of Head of Femur. Surg. Gynec. Obstet., LIX, 415, 1934.

POTTS, F. N., AND OBLETZ, B. E.: Aseptic Necrosis of Head of Femur Following Traumatic Dislocation. J. Bone and Joint Surg., XXI, 101, Jan. 1939.

SCHROEDER, W. E.: Fracture of the Acetabulum with Displacement of the Femoral Head into the Pelvic Cavity. Quart. Bull. Northwestern Univ. Med. School, XI, 9, 1909.

SENN, N.: A Contribution to a Knowledge of Fracture of the Rim of the Acetabulum, Based on the Reports of Twenty-Seven Cases and Experiments on the Cadaver. Trans. State Med. Soc. Wisconsin, XIV, 91, 1880.

STEWART, W. J.: Aseptic Necrosis of the Femoral Head of the Femur Following Traumatic Dislocation of the Hip Joint. J. Bone and Joint Surg., XV, 413, Apr. 1933.

STIMSON, L. A.: A Practical Treatise on Fractures and Dislocations. p. 359. New York, Lea & Febiger, 1917.

VIREVAUX, M. J. B. J.: Des enfoncements traumatiques de la cavité cotyloïde; étude expérimentale et clinique. pp. 57–66. (Thèse) Lyon, 1899.

WHEELER, W. I. DE C.: Some Practical Considerations in the Conservative Treatment of Fractures of the Pelvis and Lower Extremity. Lancet, II, 313, 1925.

ADDUCTION TRACTION IN TROCHANTERIC FRACTURES

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The accepted management of treating fractures about the hip joint, other than fractures of the neck of the femur, has followed the rule of approximating the distal fragment to the uncontrollable proximal fragment, with the thigh in abduction and flexion. The authors have recently discarded this practice for what they consider a better method.

Over a period of ten years, about 1,500 intertrochanteric fractures were treated on the Fracture Service by traction in a Thomas splint suspended in a Balkan frame, with the thigh flexed and abducted. For years the results were accepted as satisfactory. Although shortening and coxa vara deformity were frequent, only one non-union, in a pathological fracture, was observed.

The disadvantages of traction methods are minor when compared to the hazards of spica plaster casts which often result in high mortality and poor maintenance of reduction.

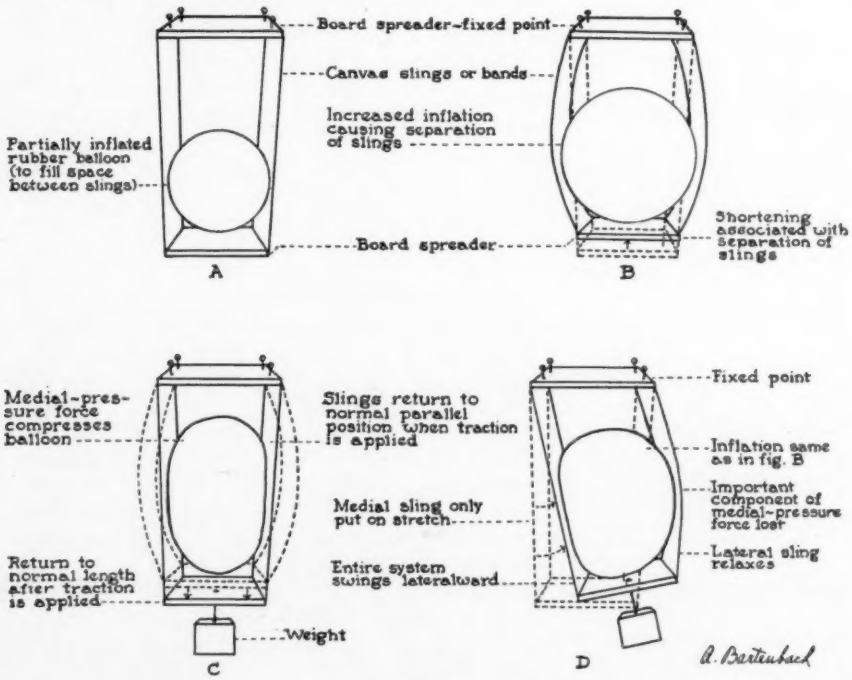
Board spreader-fixed point
Canvas slings or bands
Increased inflation causing separation of slings
Partially inflated rubber balloon (to fill space between slings)
Board spreader
Shortening associated with separation of slings
A
B
Medial-pressure force compresses balloon
Slings return to normal parallel position when traction is applied
Fixed point
Inflation same as in fig. B
Important component of medial-pressure force lost
Medial sling only put on stretch
Lateral sling relaxes
Return to normal length after traction is applied
Entire system swings lateralward
Weight
C
D
A. Breitenbach

FIG. 1

Mechanical principles involved in treating intertrochanteric, pertrochanteric, and subtrochanteric fractures in adduction instead of abduction traction.

Some have advocated the flanged nail in trochanteric fractures, which often splits the bone; but even if this fails to occur, the method does not permit the patient to be up any sooner than the eight weeks required for closed traction[2].

Seeking improvement in the reduction of these fractures, the authors have applied the method of longitudinal parallel ligament and muscle pull, as used in the reduction of Pott's fracture with separation of the tibiofibular articulation[1].

The new method applies a physical law. When two parallel bands lose their parallel position, equal force applied in their longitudinal axis realigns the bands (Figs. 1*A*, 1*B*, and 1*C*).

If, for example, a partially inflated rubber balloon is placed between these parallel bands (Fig. 1*A*), they remain parallel, but, if the balloon is still further inflated, the bands lose their parallel position (Fig. 1*B*). However, traction in the longitudinal axis tends to parallel the bands, and a lateral force compresses this ball with a force equal (approximately) to the traction force (Fig. 1*C*). If the lower board spreader is moved lateralward and tilted, as would occur in abduction of the leg, one sling is relaxed (Fig. 1*D*), and, when traction is applied, the effect of the medial pressure force is lost for the most part on the lateral side. Here, and in Figure 2*D*, the pelvic tilt is omitted for the sake of clarity.

The coxa vara deformity in hip fractures is the inflated space, as in

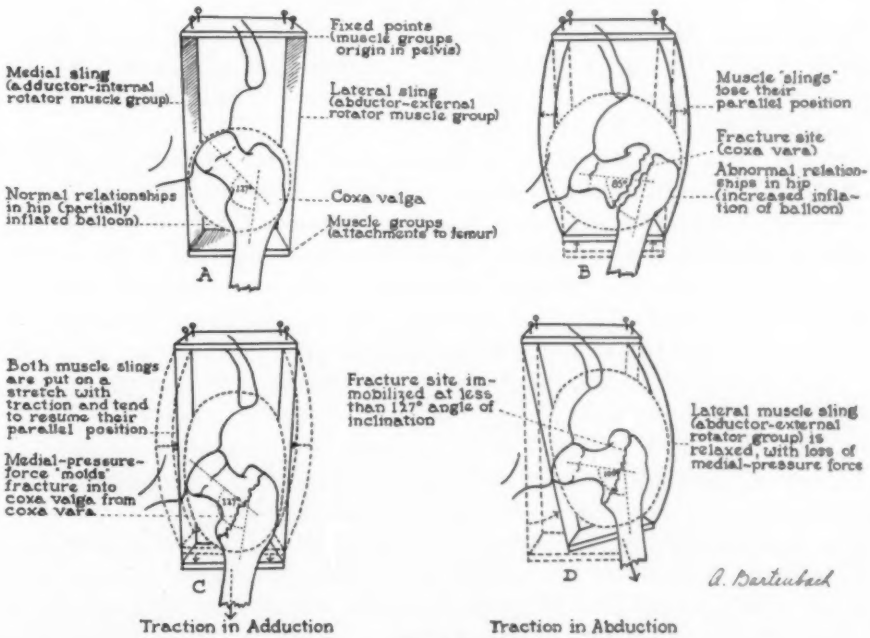
Fixed points (muscle groups origin in pelvis)
Medial sling (adductor-internal rotator muscle group)
Lateral sling (abductor-external rotator muscle group)
Normal relationships in hip (partially inflated balloon)
Coxa valga
Muscle groups (attachments to femur)
A
Muscle "slings" lose their parallel position
Fracture site (coxa vara)
Abnormal relationships in hip (increased inflation of balloon)
B
Both muscle slings are put on a stretch with traction and tend to resume their parallel position
Medial-pressure-force "molds" fracture into coxa valga from coxa vara
C
Traction in Adduction
Fracture site immobilized at less than 127° angle of inclination
Lateral muscle sling (abductor-external rotator group) is relaxed, with loss of medial-pressure force
D
Traction in Abduction
A. Bartenbach

FIG. 2

Mechanical principles applied to specific fracture,—that is, the analogous situation as applied to the anatomy of the hip. In *D* the pelvic tilt has been omitted to show the mechanical principle more clearly.

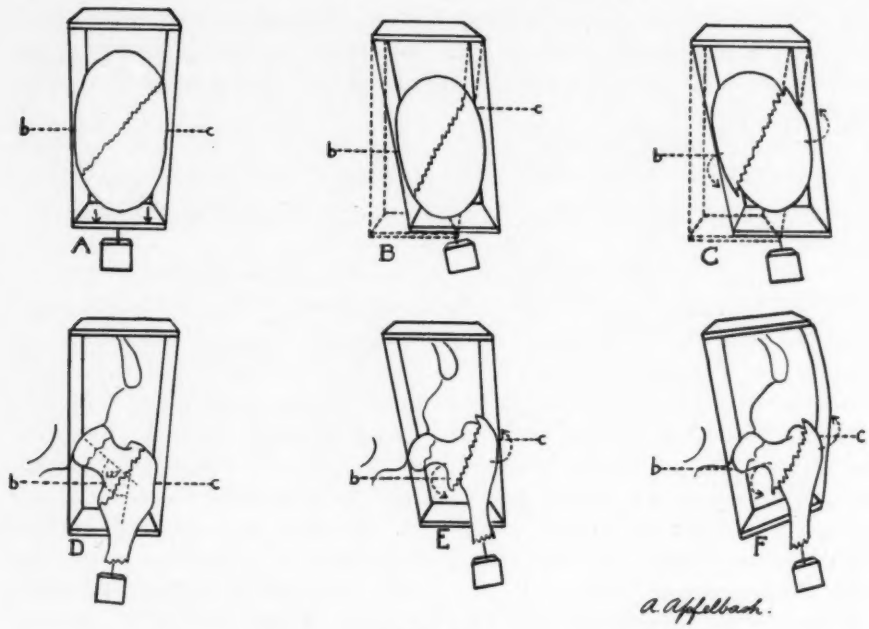

FIG. 3

Mechanical principles of circular-friction rotation applied to the treatment of intertrochanteric, pertrochanteric, and subtrochanteric fractures in abduction traction.

the balloon. If traction is applied equally to the adductors and abductors with the leg in adduction, the parallel force molds the fracture into a coxa valga position, while the traction restores the length of the limb (Fig. 2*C*).

In abduction traction the pelvis does not remain a fixed point, but tilts upward because the limbs of the patient tend to parallelism. Therefore, in many intertrochanteric fractures parallel ligament and muscle pull is obtained in abduction, so that good reduction may result. The authors have observed, however, that the pelvis does not always tilt in proportion to the abduction of the thigh, so that abduction with parallel ligament and muscle pull is not fully attained.

Another disadvantageous force, in abduction traction, is that of circular-friction rotation.

If an egg-shaped solid, cut obliquely in halves, is substituted for a balloon in the rectangular parallelogram, the pressure produced by the bands at points *b* and *c* is equal and at the same level, and there is no friction rotation (Fig. 3*A*); however, if, in the lateral swing, the parallelogram is maintained, the pressure by the bands will be equal on both sides of the solid, but at different levels (Fig. 3*B*), so that the circular friction force will move one half upward and the other half downward (Fig. 3*C*). In adduction traction in an intertrochanteric fracture, pressure at *b* and *c* neutralizes friction rotation because the pressure occurs at equal levels (Fig. 3*D*), and hence no displacement will occur.

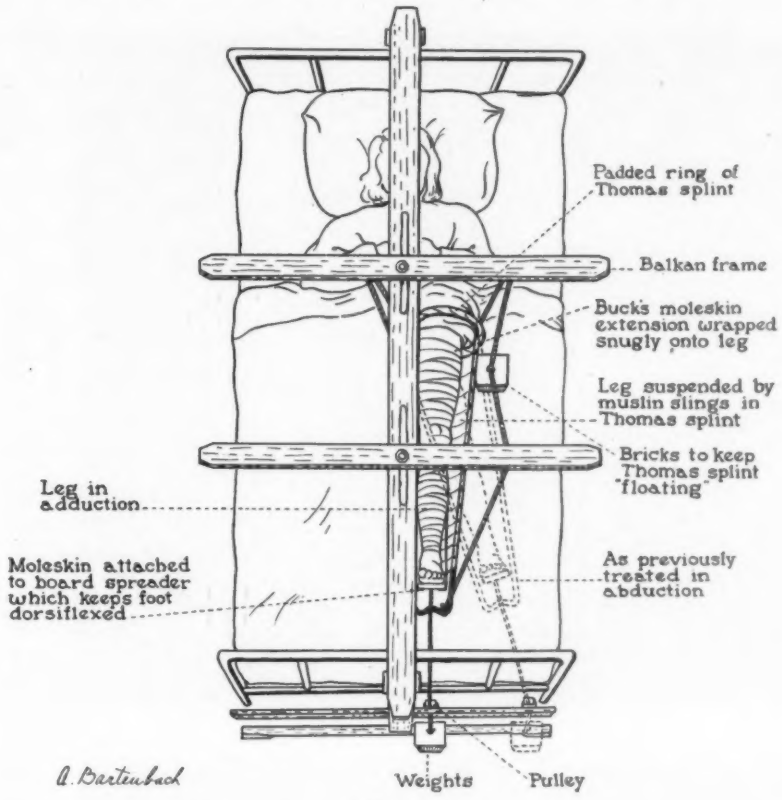
Padded ring of Thomas splint
Balkan frame
Bucks moleskin extension wrapped snugly onto leg
Leg suspended by muslin slings in Thomas splint
Bricks to keep Thomas splint floating
Leg in adduction
Moleskin attached to board spreader which keeps foot dorsiflexed
As previously treated in abduction
A. Bartenbach
Weights
Pulley

Fig. 4

The method used in applying the principle of traction in adduction, instead of abduction.

By substituting for the ovate solid the fractured trochanter in abduction traction (Fig. 3*E*), coxa vara deformity will be produced by circular friction rotation. A parallelogram such as is shown in Figure 3*E* can occur only when the pelvis does not tilt with abduction. Since this seldom occurs, coxa vara deformity is caused by laxity of the lateral ligaments and muscles, and by circular-friction rotation (Fig. 3*F*). In other words, coxa vara deformity may be caused by laxity of the lateral ligaments, by circular-friction rotation, or by both forces acting together. Therefore, to avoid failure in the extension of intertrochanteric fractures, the leg should never be abducted, but should be placed in adduction.

Observations were made on eighty-five cases of intertrochanteric, subtrochanteric, and pertrochanteric fractures. In seventy of these, traction in adduction was employed. In fifteen, equal weights were used, but the thigh was flexed and abducted. In none of the controls was the reduction as perfect nor the angle as ideal as by the newer method. In adduction the fractures healed consistently in coxa valga.

On admission to the ward, patients with hip injuries are immedi-

FIG. 5-A

FIG. 5-B

Case 1. Patient, female, aged sixty-two, fell on icy sidewalk, and was put in adduction traction. After nine weeks of traction, there was union in coxa valga.

Fig. 5-A: Fracture before traction was begun.

Fig. 5-B: Five days after traction in adduction, 135 degrees of coxa valga had been obtained.

FIG. 6-A

FIG. 6-B

Case 2. Patient, female, aged sixty-nine, slipped on icy pavement, fell on hip, and was placed in adduction traction three hours later.
Fig. 6-A: Shows coxa vara deformity.
Fig. 6-B: After traction of thirty-five pounds for four days, reduction in coxa valga of 170 degrees was obtained.

FIG. 7-B

FIG. 7-A

Case 3. Patient, female, aged seventy-five, slipped and fell on an icy sidewalk, and was taken to the hospital within six hours.
Fig. 7-A: Intertrochanteric fracture with coxa vara of 100 degrees.
Fig. 7-B: Four days after traction in adduction of thirty-five pounds, there was coxa valga of 140 degrees.

FIG. 8-B

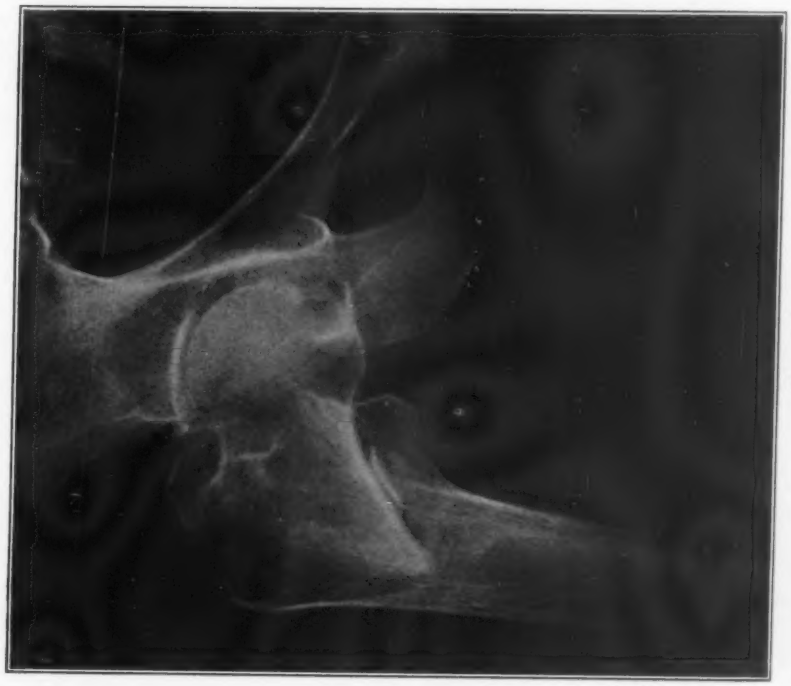

FIG. 8-A

Case 4. Patient, female, aged fifty-eight, fell in kitchen, and was taken to the hospital four hours later.
Fig. 8-A: Intertrochanteric fracture with coxa vara of 90 degrees.
Fig. 8-B: After one week in adduction traction, there was coxa valga of 130 degrees.

ately put in traction. The moleskin should not overlap nor overlie unprotected bony prominences. The sheet wadding which pads the ring of the Thomas splint should be wrapped clockwise, not spirally, before being covered by muslin bandage.

With the leg in adduction and very little flexion, traction of thirty to forty pounds is applied. A roentgenogram on the fourth or fifth day usually shows a coxa valga reduction. The weights are then gradually reduced so that only fifteen to twenty pounds are necessary at the end of the fourth or fifth week. The foot of the bed is elevated for countertraction.

Reductive union occurs in eight weeks, but the cancellous bone of the trochanter does not tolerate weight-bearing for at least six months. The patient is allowed out of bed at the end of eight weeks, using a walking caliper with crutches, and later with a cane for six months, until callus tenderness has disappeared.

CONCLUSION

Better reductions in hip fractures, other than those in the femoral neck, are obtained by applying longitudinal parallel ligament and muscle pull than by the commonly accepted principle of approximating the lower to the upper fragment. Straight traction in adduction is used instead of traction in abduction and flexion.

REFERENCES

1. Apfelbach, George, and Boim, Leon: Fractures of the Ankle. Arch. Surg. XXXV, 328, 1937.
2. Key, J. A.: Internal Fixation of Trochanteric Fractures of the Femur. Surg., VI, 13, 1939.

TIBIAL TORSION ACCOMPANYING CONGENITAL CLUB-FOOT

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Several authors have called attention to the internal-rotation deformity within the long axis of the tibia, which not infrequently accompanies congenital club-foot. Thus every one interested in the treatment of club feet recognizes this concomitant deformity, but opinion is divided with regard to its correction. Campbell in his recent book stated that, with rare exception, the internal-rotation deformity of the tibia may be disregarded from a surgical viewpoint. In an endeavor to clarify his own position, the author reviewed a series of sixty-two consecutive cases of congenital club feet that had been followed for periods varying from two to five years, and the conclusion was reached that not only does tibial torsion accompany club-foot in a higher percentage of cases than was formerly believed, but it also occurs in sufficient degree to warrant surgical correction.

It was during the follow-up period on some cases of bilateral club-foot

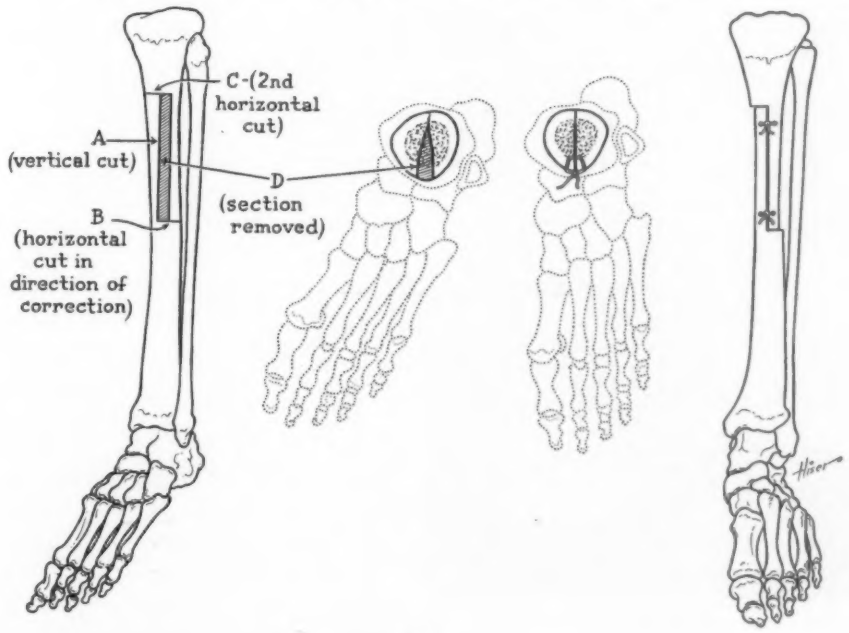

FIG. 1

Diagram of controlled rotation osteotomy, the type used and preferred by the author for correcting internal torsion of the tibia. (Adapted from O'Donoghue.)

that attention became focused upon tibial torsion as a factor in recurrence of the deformity. The author was seeking the reason behind the recurrence of the adduction deformity in only one foot, although both feet had been thoroughly corrected and checked by roentgenograms. In a previous paper [4] it was noted that adduction was the chief deformity recurring in those feet which relapse, and closer observation has now revealed that in over 90 per cent. of these cases tibial torsion was present in the leg which showed recurrence and absent in the other which had maintained its correction.

ANATOMY

Before the equinovarus deformity has been corrected it is often difficult to determine whether internal rotation of the tibia is present, or if present, to what degree. However, after the equinovarus has been corrected and the child is walking, it is easy to detect tibial torsion, since the child invariably "toes in" on the affected side. A line dropped from the anterior superior spine of the ilium, bisecting the patella, will fall to the lateral border of the foot outside the little toe, instead of between the great and second toes as is normal. With the patella pointing straight forward, palpation of the malleoli at the ankle will show the external malleolus to be anterior to the medial malleolus instead of parallel to it as is normal. Thus, when the child is walking, the weight-bearing thrust falls obliquely across the long axis of the foot and drives the scaphoid around to the medial side of the head of the talus with re-creation of the adduction deformity of the forefoot. If this same vicious force is allowed to continue, varus of the heel and inversion of the foot will follow the adduction deformity. These undesirable sequelae to correction of clubfoot can be obviated if a rotation osteotomy of the tibia is done when tibial torsion is present.

FIG. 2-A

Case 1. Severe bilateral congenital equinovarus in a patient, three years of age, who had had no previous treatment.

INDICATION FOR CORRECTION

One hesitates to draw a hard and fast limit to the degree of deformity which requires attention, since correction means an open operation on a young child. The author feels, however, that no tibial torsion of 15 degrees or more should be disregarded, and in this series all

patients operated on had a deformity of 20 degrees or more. There is an advantage in derotating the tibia as soon as the foot is corrected, because the child is already accustomed to the plaster casts. Occasionally a trial in weight-bearing may become necessary to convince the parents that the deformity will most surely recur. In this series those children with tibial torsion who were allowed to walk before this was corrected relapsed into adduction within from five to twelve months.

OPERATIONS

Some authors advocate the application of long leg casts with the knees held at right angles while correcting the equinovarus, adding an external twist to the long axis of the lower leg in an attempt to correct the internal tibial torsion, but any force aimed at correcting tibial torsion by this method is lost in the knee joint, and instead of correcting the deformity may produce an undesired laxity in the structures within and around the knee joint. There are described in the literature at least three operations for derotating the tibia, and a short résumé of each will indicate the author's preference for one type.

A. *Transverse Osteotomy*

This is the simplest and probably the oldest operation for this type of deformity. A transverse cut through the tibia is made about one inch

FIG. 2-B

FIG. 2-C

Fig. 2-B: Case 1. One year later, the feet have been corrected by the conservative multiple-cast method. Patellae are marked to show the inward torsion in the long axis of the left tibia.

Fig. 2-C: Case 1. Three months later than Fig. 2-B, following controlled rotation osteotomy of the left tibia. Note proper alignment between knee and foot.

below the proximal epiphyseal plate, and the distal fragment is rotated externally on the proximal fragment. This operation is unsatisfactory principally for three reasons:

1. Some of the correction takes place in the knee joint since the upper fragment also rotates externally.
2. Fixation depends upon the plaster cast.
3. Angulation may take place at the level of the osteotomy. (Three cases of genu valgum have been seen following transverse osteotomy for tibial torsion.)

B. *Longitudinal Osteotomy*

This is an operation described by Haas, wherein multiple longitudinal incisions are made in the upper end of the tibia parallel to its long axis and separated from each other by narrow strips of cortex. This operation is an improvement over the transverse osteotomy because angulation at the operative site is prevented, but loss of correction can still take place in the knee joint and fixation depends upon the external plaster cast.

C. *Controlled Rotation Osteotomy*

This is an operation devised by O'Donoghue and is preferred by this author because it is technically foolproof. The plan of operation is a Z osteotomy in a circular tube of bone, with removal of a strip of cortex to allow rotation. A longitudinal saw cut is made through the anterior cortex of the upper one third of the tibia, about two inches in length and parallel to the crest. The two horizontal cuts (the arms of the Z) are next made, one at each end of the longitudinal cut. The distal horizontal cut is made in the same direction as that of the desired correction, that is, outward or to the lateral border of the tibia; the proximal cross cut is exactly opposite or towards the medial border of the tibia. The linear section of the posterior cortex is completed by driving an osteotome through the long longitudinal saw cut. The tibia has then been divided into two long opposed fragments still hinged together on the posterior surface by a small portion of the posterior cortex. A longitudinal strip of cortex is removed by making a second longitudinal cut parallel to the first, the width of the strip being predetermined by the amount of rotation desired. With the edges of the longitudinal cut placed in approximation, one can determine how much

FIG. 3-A

Case 2. Bilateral congenital equinovarus corrected by the conservative multiple cast method. Note the marked internal torsion of the left tibia with malalignment of the foot and knee.

correction has been obtained, and more can be secured if necessary. Finally the edges of the longitudinal cut are held in approximation by sutures placed through opposing drill holes at each end of the longitudinal cut. This operation has the following advantages over the other types of osteotomy:

1. The amount of rotation desired is gained in the tibia and nothing is lost in the knee joint.
2. The fragments are fixed internally, reducing to a minimum the chances for postoperative distortion.
3. The cast serves only to protect the leg, and is not utilized to obtain or maintain correction.
4. There is a large surface for callus which affords quick healing.

FIG. 3-B

Case 2. Showing the immediate position after rotation osteotomy. The plaster cast has been cut over the dorsum of the foot to allow stretching of the heel cord during the convalescent period.

The illustrations used in this article are photographs of two typical cases chosen from among the sixty-two which constitute the basis for this report.

SUMMARY

1. Internal tibial torsion accompanies club-foot in a fair percentage of cases (17 per cent. in this series).

2. It is a major factor in recurrence of the club-foot deformity.

3. Tibial torsion of 15 degrees or more should be treated surgically after the equinovarus deformity has been corrected.

REFERENCES

1. Campbell, W. C.: Operative Orthopedics. St. Louis, C. V. Mosby Co., 1939.
2. Haas, S. L.: Longitudinal Osteotomy. J. Am. Med. Assn., XCII, 1656, 1929.
3. O'Donoghue, D. H.: Controlled Rotation Osteotomy of the Tibia. Southern Med. J., XXXIII, 1145, 1940.
4. Sell, L. S.: The Conservative Treatment of Congenital Club Feet in Infants. Southern Med. J., XXXII, 1199, 1939.

EXAMINATION OF THE SHOULDER FOR CALCIUM DEPOSITS

Technique of Fluoroscopy and Spot-Film Roentgenography

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Not infrequently calcium deposits in the region of the shoulder joint are discovered accidentally in roentgenograms of the chest or upper extremity. Usually the patient is unaware of the presence of the calcium; the physician regards it as merely an incidental finding of no clinical significance, and nothing further is done about it. Lately, however, more interest has been shown in these deposits, and their importance as a potential source of pain and disability is now generally recognized [2, 3, 4, 6, 10, 11].

Although various roentgenographic techniques in the examination of the shoulder for calcium deposits have been recommended [1, 7, 8], no one has stressed the importance of fluoroscopy as a preliminary procedure for the detection of calcium, or advocated the combination of spot-film roentgenography with fluoroscopy as the best means of recording the precise location of such deposits. Elsewhere [2] are presented the results of a three-year survey of over 6000 supposedly normal individuals whose shoulders were fluoroscoped for calcium deposits, most of them several times, at intervals of a year or less.

In a study of this nature, fluoroscopy was found to be preferable to roentgenography alone for several reasons. Deposits may be overlooked in a roentgenogram when they are superimposed upon the head of the humerus or the overlying acromion (Figs. 1-A, 1-B, 1-C, 1-D, 1-E, 4-A, 4-B, and 4-C). The density of the shadow cast by deposits on the roentgenogram varies greatly. The calcium is usually spread out in a thin layer which casts little shadow unless it is so placed between tube and film that the roentgen rays have to traverse the length or breadth rather than the thickness of the deposit (Figs. 4-A, 4-B, and 4-C). If examination is restricted to roentgenography, many roentgenograms should be taken of each shoulder in different planes and with varying degrees of humeral rotation. Even then calcium collections, which would be seen on fluoroscopy, may be missed entirely. The expense of such an examination and its inherent element of error are self-evident.

Fluoroscopy, properly performed, makes visible very nearly the full extent of the shoulder-joint capsule within the space of a few moments. It is effective, speedy, and relatively inexpensive. It is as useful in inspecting the shoulder as it is in the examination of the gastro-intestinal tract. Due to its simplicity of application and low cost, it furnishes an ideal means not only for detecting the presence and position of calcium deposits, but for following their course from month to month or year to

FIG. 1-A

FIG. 1-B

FIG. 1-C

FIG. 1-D

FIG. 1-E

Case 1. C. H., aged thirty-two, female, clerk. Multiple calcium deposits were detected by fluoroscopy and photographed by spot-film technique.

Fig. 1-A: Right shoulder, external rotation. Only one small deposit may be seen in the supraspinatus.

Fig. 1-B: Right shoulder, mid-rotation. The deposit seen in Fig. 1-A is now hidden by the humeral head and another small deposit, in the infraspinatus, comes into view.

Fig. 1-C: Left shoulder, external rotation. A small deposit is visible in the supraspinatus and there is the suggestion of another deposit superimposed on the head of the humerus.

Fig. 1-D: Left shoulder, mid-rotation. The supraspinatus deposit has disappeared from view and an infraspinatus deposit, a suggestion of which is seen in Fig. 1-C, has now come around into profile.

Fig. 1-E: Left shoulder, internal rotation. Neither of the deposits shown in Figs. 1-C and 1-D is longer visible, but an unsuspected little deposit in the teres minor has been brought into view.

FIG. 2-A FIG. 2-B FIG. 2-C

Case 2. J. F., aged thirty-five, female, typist. Spot-film technique reveals the gradual absorption and disappearance of a large deposit. There is no hit-or-miss in this method. The site of the deposit may easily be shown in profile at each successive examination.

Fig. 2-A: December 27, 1938. Large calcium deposit in the supraspinatus portion of the short rotator cuff, left shoulder.

Fig. 2-B: January 30, 1939. The deposit is smaller; much has been absorbed.

Fig. 2-C: July 26, 1939. Just a thin line of calcium remains to mark the site of the deposit. When the arm was rotated a few degrees, this thin line disappeared completely, due to its superimposition upon the head of the humerus.

FIG. 3-A

FIG. 3-B

Case 3. J. B., aged fifty-one, male, clerk. By spot-film roentgenography calcium deposits may be photographed in the same relative position after the lapse of months or years, as shown in these roentgenograms.

Fig. 3-A: Right shoulder. A large calcium deposit which has diffused into the subacromial bursa. This is the "fluffy" type of deposit which is most apt to be absorbed.

Fig. 3-B: Right shoulder. Two months later, the deposit is nearly gone.

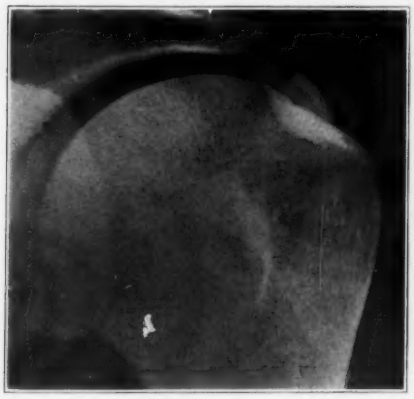

FIG 3-C

FIG. 3-D

Fig. 3-C: Left shoulder. A large calcium deposit still within the substance of the tendinous short-rotator cuff. The deposit is dense and sharply outlined.

Fig. 3-D: Left shoulder. Two years later, the deposit is shown in the same degree of rotation. It has increased in size and in density.

year. In this way any increase or decrease in size may easily be checked and the effect of treatment observed (Figs. 2-A, 2-B, 2-C, 3-A, 3-B, 3-C, and 3-D). Regardless of whether or not roentgenograms are taken, fluoroscopy should never be omitted as an essential part of the examination, and both shoulders should always be inspected, since nearly 50 per cent. of those individuals with calcium in one shoulder will show it in the other shoulder as well [2]. No shoulder should ever be declared free of calcium on the basis of roentgenographic evidence alone; fluoroscopy is the final arbiter (Figs. 4-A, 4-B, and 4-C).

The fluoroscopic technique used in looking for calcium is highly

important. Each shoulder in this series was examined fluoroscopically throughout its full range of motion, with the individual standing. The author believes the erect position is an advantage, as thereby gravity, acting through the weight of the arm, tends to widen the joint space, and to prevent superimposition of the acromion on the soft tissues which are being inspected. Standing, also, is the most comfortable examining position for the patient with a painful deposit, as it helps to avoid pinching the deposit between the head of the humerus and the acromion.

Various degrees of arm rotation produce characteristic roentgenographic profiles which may easily be recognized (Figs. 1-A, 1-B, 1-C, 1-D, and 1-E). The outstanding anatomical features which serve to differentiate and identify them may be summarized as follows:

1. *External Rotation* (Figs. 1-A and 1-C)

a. The upper outer border of the humeral head has a definite protruding angle formed by the greater tuberosity.

b. A notch or sulcus above the greater tuberosity represents the site of the supraspinatus insertion.

c. The lesser tuberosity stands out in profile, parallel to and medial to the greater tuberosity.

d. The bicipital sulcus is well marked as a vertical groove between the tuberosities.

e. The medial surface of the head is a smooth hemisphere formed by the articular surface, with an indentation below it at the junction of the articular surface with the humeral shaft.

f. The greater tuberosity often has a cystic appearance, a circular area of decreased density about the size of a twenty-five-cent piece, which represents the epiphyseal outline. This has been seen in adults as well as adolescents.

2. *Mid-Rotation* (Figs. 1-B and 1-D)

a. The upper outer border of the humeral head is now a rather flat or slightly rounded oblique plane.

b. The tuberosities and bicipital sulcus are no longer clearly outlined.

c. The hemispherical articular surface remains, but its axis is tilted further upward and the indentation below it is less marked.

d. The cystlike appearance of the greater tuberosity (Figs. 5-A and 5-B), if present, becomes more distinct, due to removal of the previously interposed lesser tuberosity. The size and shape of the "cyst" remain essentially unchanged. Such "cysts" must not be confused with bone cysts, giant-cell tumors, fractures, or other pathological conditions of the proximal end of the humerus. A lack of appreciation of their true nature has been responsible for more than one needless operation [5, 9].

3. *Internal Rotation* (Fig. 1-E)

a. The rounded curve of the articular surface now occupies the outer

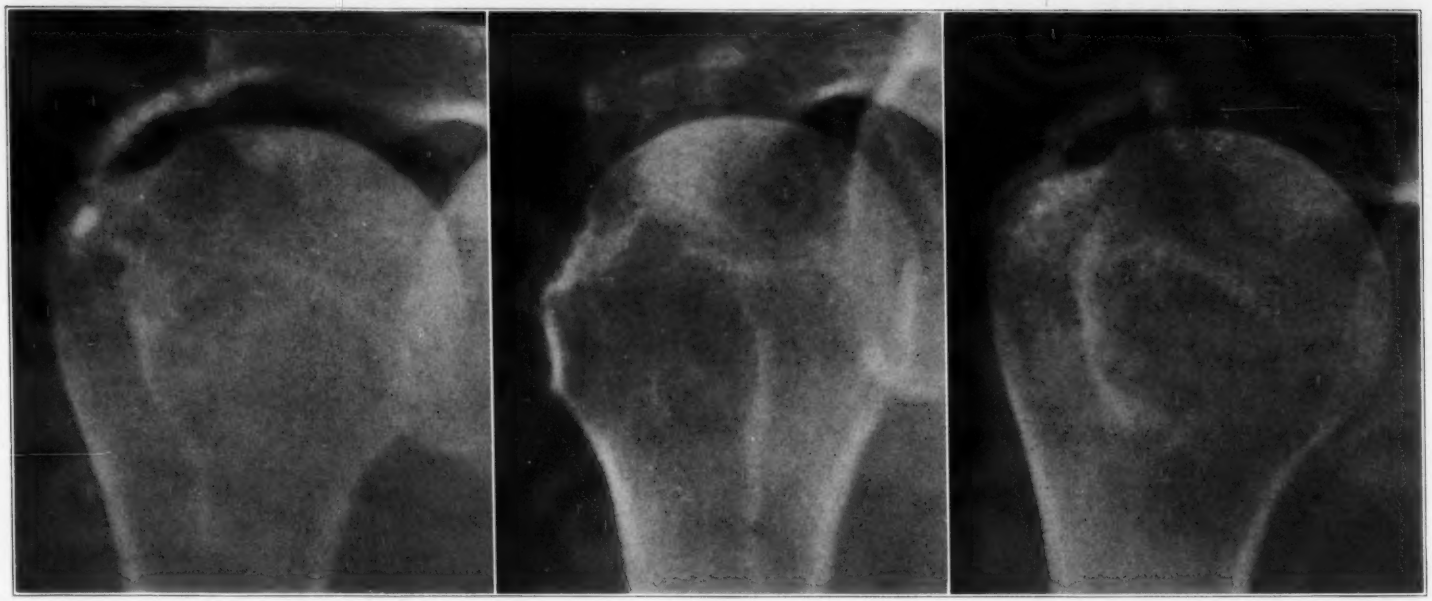

FIG. 4-A FIG. 4-B FIG. 4-C

Case 4. T. R., aged fifty-two, female, clerk. These roentgenograms, taken without fluoroscopy, show how easy it is to miss even a large deposit when roentgenographic examination alone is relied upon.

Fig. 4-A: Large deposit in supraspinatus portion of the short-rotator cuff, right shoulder.

Fig. 4-B: Two weeks later, the deposit seems to have disappeared; actually it is hidden by the superimposed humeral head and acromion process, due to rotation of the arm.

Fig. 4-C: Two months later, a roentgenogram taken with the arm in its original position shows that the deposit is still present.

FIG. 5-A

FIG. 5-B

Case 5. D. G., aged eighteen, female, clerk. Cystic appearance of the greater tuberosity of both shoulders, found upon routine fluoroscopic examination. There were no symptoms. Physical examination was negative. Nothing was found to suggest a pathological process. Apparently normal shoulders frequently present this cystic appearance upon fluoroscopy.

Fig. 5-A: Right shoulder, mid-rotation.

Fig. 5-B: Left shoulder, mid-rotation.

portion of the head, with its axis pointing up and out. The indentation beneath it appears on the outer border of the shaft.

b. The tuberosities and the bicipital groove reappear on the medial portion of the head, but they are less distinct than they were on external rotation.

c. The cystlike appearance of the greater tuberosity, if previously

FIG. 6-A

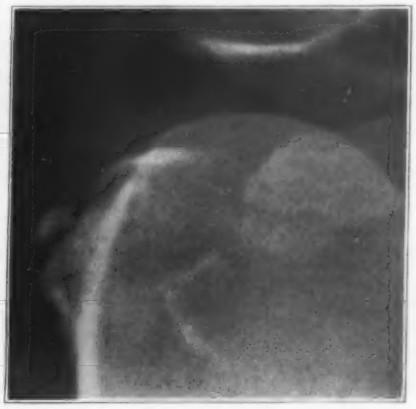

FIG. 6-B

Case 6. G. R., aged forty-nine, male, clerk. This case illustrates the special fluoroscopic technique used to bring a subscapularis deposit into profile (See text).

Fig. 6-A: Right shoulder. External rotation fails to show clearly a large calcium deposit in the subscapularis portion of the short-rotator cuff.

Fig. 6-B: Right shoulder. External rotation plus body rotation throws the deposit clearly into profile.

FIG. 7-A

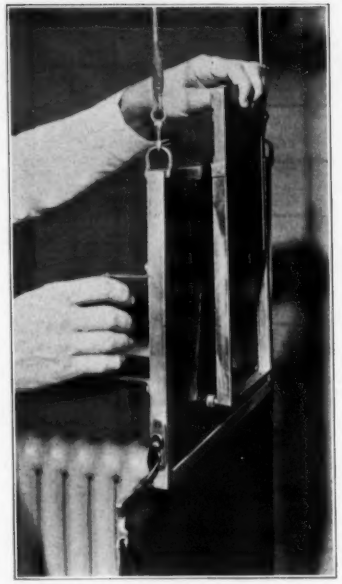

FIG. 7-B

FIG. 7-C

Fig. 7-A: The cassette holder.

Fig. 7-B: The cassette holder is hung on a fluoroscope screen. A cassette is being inserted.

Fig. 7-C: Set-up for fluoroscopy and spot-film roentgenography in the home. The cassette holder is supported by a double-jointed bracket which is clamped at one end to the holder, and at the other, to a chair.

seen, has disappeared, owing to superimposition of the lesser tuberosity on the greater, and of the glenoid fossa of the scapula on both.

The anatomical basis for these roentgenographic features will be appreciated upon an inspection of the disarticulated skeleton. Naturally intermediate degrees of rotation produce roentgenographic landmarks to some extent at variance with the above descriptions, but they will show a preponderance of the basic characteristics of one of these three positions.

A knowledge of how these positions may be obtained is essential for any one who desires to secure exactly comparable views at successive examinations. Full external rotation (Figs. 1-A and 1-C) is secured with the arm at the side, the elbow close to the body, and the forearm, flexed to a 90-degree angle, pointed as far laterally as possible. In mid-rotation (Figs. 1-B and 1-D), the arm occupies a similar position alongside the body, but the flexed forearm is pointed straight forward in the sagittal plane. For extreme internal rotation (Fig. 1-E), the flexed forearm is placed behind the back or, if this is impossible, on the chest. To view the lesser tuberosity with the subscapularis insertion in profile, the arm is placed in full external rotation and then the body is turned a few degrees in the same direction; if the body is not turned as well, the region of the lesser tuberosity will not be seen in profile and deposits in the subscapularis portion of the cuff may escape notice (Figs. 6-A and 6-B).

In the early days of this investigation an attempt was made to instruct the individual, during fluoroscopy, in what position the arm should be held, so as to bring the deposit into profile for subsequent roentgenography. This procedure soon had to be abandoned, however, because of the frequency with which a degree or two of rotation one way or the other from the correct position obscured the deposit. Time after time a deposit clearly seen by fluoroscope failed to appear on films taken later, simply through failure to have the arm in exactly the right position during roentgenography. This led to the development and adoption of the spot-film technique to be described.

With the deposit shown in profile by fluoroscope, a roentgenogram is taken, using a cassette holder (Figs. 7-A and 7-B), especially devised for that purpose, which is hung on the screen before fluoroscopy. The holder is a simple affair of channel brass, cut, bent, and brazed, according to a homemade pasteboard pattern, to fit a chosen cassette. It is readily fashioned by one mechanically inclined. Proper exposure can quickly be determined by trial and error; a short tap of the foot-switch (or a quarter of a second on the timer) sufficed in the author's experience.

In addition, the cassette holder has a small knob brazed to its under surface. By this means the holder may be supported by a jointed bracket, independent of the fluoroscopic screen. One end of the bracket is clamped to a chair, table, or stand, and the other end to the knob mentioned above (Fig. 7-C). This makes it possible for the owner of a small portable fluoroscope to employ the spot-film roentgenographic technique in the home as well as in the office.

FIG. 8-A

FIG. 8-B

Case 7. A. K., aged thirty-seven, female, clerk. Three views of the same deposit; only one (Fig. 8-A) shows the deposit in profile, thereby accurately localizing it, before operation, in the supraspinatus portion of the short-rotator cuff.

Fig. 8-A: External rotation. Fig. 8-B: Mid-rotation.

FIG. 8-C

Internal rotation.

It should be emphasized in this connection, however, that both fluoroscopy and roentgenography are inherently dangerous procedures, the indiscriminate use of which cannot be too strongly condemned. They should be undertaken only by those thoroughly aware of the possibility of burn to the operator, to the patient, or to both, either through overexposure or through the cumulative effect of repeated exposures. Fluoroscopic examination is particularly dangerous. Due to natural interest in, and concentration upon, the examination itself, one is apt to overlook the factor of exposure. The very simplicity and effectiveness of the procedure tend to make even an experienced operator careless in the course of time, and he must constantly check himself as to the protective measures he observes, and the amount of exposure to which he subjects himself. It is not enough to rely upon leaded gloves and apron and the use of a hand timer instead of a foot switch. They are no substitute for a careful training in roentgenographic technique, and this should be obtained before undertaking the procedures advocated in this paper.

Precise localization of the deposit by a technique such as that described is most important when operative removal of the calcium is contemplated. Figures 8-A, 8-B, and 8-C show three roentgenograms of a

shoulder, all taken at the same examination. It is evident that only one of the three (Fig. 8-A) was of value, from a surgical standpoint, in exactly locating the calcium deposit in the supraspinatus portion of the short-rotator cuff. Any one who has operated to remove these deposits will appreciate the extra advantage of thus knowing beforehand exactly where to look for the deposit.

In the event of multiple deposits in the same shoulder, a fairly common occurrence [2], as many as three or four roentgenograms are taken at one examination, rotating the arm under fluoroscopic control between exposures, to show each deposit in profile (Figs. 1-A, 1-B, 1-C, 1-D, and 1-E).

Roentgenography according to the above procedure necessarily suffers a slight distortion, mostly an enlargement of the roentgenographic shadow, due to proximity of the object to the tube; yet this magnification often proves to be an advantage, as it makes small deposits more visible. The spot-film method also involves the loss of a very small amount of photographic definition, but when fine bone detail is desired, further roentgenograms may be taken according to standard techniques [1]. Incidentally, the small size of film (five by seven inches or less) required by this method represents a material saving.

In conclusion, it is well to repeat that roentgenograms taken without fluoroscopic inspection and control frequently fail to show calcium deposits in the shoulder, the presence of additional deposits, or the precise location of the calcium within the tendinous capsule of the joint.

REFERENCES

1. Blackett, C. W., and Healy, T. R.: Roentgenography. Am. J. Roentgenol., XXXVII, 760, 1937.
2. Bosworth, B. M.: Calcium Deposits in the Shoulder and Subacromial Bursitis. A Survey of 12,122 Shoulders. J. Am. Med. Assn., CXVI, 2477, May 31, 1941.
3. Carnett, J. B., and Case, E. A.: A Clinical and Pathological Discussion of So-Called Subacromial Bursitis. Surg. Clin. North America, IX, 1107, 1929.
4. Codman, E. A.: The Shoulder; Rupture of the Supraspinatus Tendon and Other Lesions in or about the Subacromial Bursa. Boston, Thomas Todd Co., 1934.
5. Fray, W. W.: The Effect of Position on the Productions of Cyst-Like Shadows about the Shoulder Joint. Radiol., XXVIII, 673, 1937.
6. Hitzrot, J. M.: Surgical Diseases of the Shoulder Bursae. Ann. Surg., XCVIII, 273, 1933.
7. Liberson, F.: The Value and Limitation of the Oblique View as Compared with Ordinary Anteroposterior Exposure of the Shoulder; A Report of the Use of the Oblique View in 1,800 Cases. Am. J. Roentgenol., XXXVII, 498, 1937.
8. Massa, J.: Une nouvelle position pour l'examen radiologique de l'épaule de profil. Gaz. Méd. de France (Supp. Cah. Radiol.), XLV, 363, 1938.
9. Morton, J. J., and Fray, W. W.: Radiographic Appearances about the Shoulder Joint, with Especial Reference to Cyst-Like Shadows. Clinical Cases. Radiol., XXVIII, 668, 1937.
10. Patterson, R. L., Jr., and Darrach, William: Treatment of Acute Bursitis by Needle Irrigation. J. Bone and Joint Surg., XIX, 993, Oct. 1937.
11. Wilson, P. D.: The Painful Shoulder. British Med. J., II, 1261, 1939.

THE TREATMENT OF BENNETT'S FRACTURE-DISLOCATION OF THE FIRST METACARPAL BONE

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The stave or boxer's or Bennett's fracture is an injury owing its origin to the disparity between an individual's pugnacity and his pugilistic technique[1]. It occurs typically when the full force of a blow impinges on the flexed thumb, instead of on the fist, with direct transmission along the first metacarpal shaft. The resultant fracture consists of an oblique break through the base with lateral luxation at the metacarpocarpal joint, and the proximal fragment, or medial angle of the base, remaining in its anatomical position. This is the characteristic pattern, though various degrees of comminution may occur. It is this resemblance on the roentgenogram to the forked staff of the medieval monk which accounts for the descriptive term "stave" (Fig. 2).

FIG. 1

Normal first metacarpal bone and joint.

It is customary to treat this injury in one of two ways. The more common method involves the application of a plaster encasement, after reduction with the thumb in full abduction and pressure over the basal portion of the bone in an attempt to reduce the luxation. The other method consists of traction in adduction by moleskin, or a wire through the shaft, with the apparatus mounted in plaster on the wrist and forearm. At the Beekman Hospital the former method has been employed almost exclusively.

About half of the ninety-six fractures of the first metacarpal bone treated during the last ten years were Bennett fractures. Of these, fourteen case records were sufficiently complete to merit detailed study. The clinical courses and end results of these cases are so uniform that they can be accurately summarized in one generic case history.

The patient, invariably a husky male, strolls into the clinic complaining of a swollen tender thumb following a fight or dimly remembered mêlée. Roentgenograms confirm the clinical diagnosis. Under local or even general anaesthesia, the thumb is manipulated, and the fragments restored to the anatomical position with fluoroscopic check-up. A plaster encasement is applied with the thumb in full abduction. Check-up roentgenograms, taken the next day, show a recurrence of the displacement

FIG. 2

Bennett's fracture, showing typical stave appearance, with the fragments straddling the greater multangular bone.

FIG. 3-A

Anteroposterior view of a healed Bennett's fracture, showing how the widened, concave, new base of the metacarpal rests upon the greater multangular.

FIG. 3-B

Lateral view of a healed Bennett's fracture, showing widening and concavity of the new base of the metacarpal bone.

with most of the abduction evident in the metacarpophalangeal joint. If the patient continues to attend the clinic, and refrains from removing the plaster himself, the encasement is discarded in from three to five weeks, at which time the movement of the thumb is fairly good and not particularly painful. A few physiotherapy treatments are administered and the patient is discharged with an excellent functional result. However, roentgenograms show a structural change which is constant and, in the author's opinion, of significance in regard to the treatment of this injury. The interspace between the small medial proximal fragment and the distal displaced fragment, which consists of the rest of the metacarpal bone, is filled in with callus (See Figures 3-A and 3-B). By the end of the second month, a new joint mortise is formed, consisting of the broadened semicircular base of the healed metacarpal bone. This results in the construction of an enarthrodial (or ball-and-socket type) in place of the original diarthrodial joint (See Figure 1).

In view of the nature of the functional stress at this site, and the likelihood of recurrent trauma of the same kind as that which caused the original injury, the question arises as to whether the anatomical change which occurs, despite the best efforts to maintain the reduction, does not represent a more desirable end result than perfect reposition of the fragments with the restoration of the original joint outline.

With this viewpoint the next few cases were treated in the following typical manner: A physiotherapy treatment (radiant heat) was administered each day for the first two weeks. A narrow ace bandage was applied between treatments to the wrist and base of the thumb. The patient was allowed to use the thumb to the limits of pain. During the third week the patient was allowed to return to his occupation, unless it was exceedingly heavy work, and no further treatments were administered unless the swelling persisted. Full motion of the thumb was usually present. By the fourth week all crepitus and evident false-point motion on direct pressure over the site of injury had disappeared. At the end of the seventh week the roentgenograms showed the defect between the fragments to be filled in with a typical stave deformity of the base, of the type shown in Figures 3-A and 3-B. There was a characteristically complete range of motion of the thumb and a good grip.

If the malposition of the fragments in a Bennett's fracture is allowed to heal without reduction, a new joint mortise is formed. Thus the normal diarthrosis becomes an enarthrosis, or ball-and-socket type of joint.

In view of the difficulty of maintaining a successful reduction in this fracture-dislocation, and because of the real possibility that the joint changes mentioned above may represent a structural improvement over the normal, it is suggested that simple physiotherapy and bandaging to relieve the soft-tissue swelling constitute a shorter, simpler, and perhaps better method of treatment than that now in use.

1. BENNETT, E. H.: Fractures of the Metacarpal Bones. Dublin J. Med. Science, LXXIII, 72, 1882.

THE "PELVIC SUPPORT" OSTEOTOMY*

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Osteotomy of the upper end of the femur appears to have been performed for the first time by the American surgeon, John Barton. Since that time many types of upper femoral osteotomy have been devised and performed for special indications. In principle, these are linear or wedge osteotomies, performed at various levels and at assorted angles. Though each varies somewhat from the others, the difference between them is frequently more apparent than real. Functionally, these different procedures are essentially identical, in that they effect a medial shifting of the anatomical axis in relation to the mechanical axis of the femur. The resulting increased stability is characteristic of the group, and justifies the generic designation of "directional" osteotomy.

They have been presumed to differ radically from several other forms of osteotomy which the French[3] have called the "pelvic support" osteotomies. The two chief instances of this type are the "bifurcation" devised by Lorenz in 1917, and the operation suggested by Schanz in 1922. Though some authors have insisted that in these, as in the directional osteotomies, the beneficent effect is to be attributed to alteration in the relationship of the femoral axes, others have maintained that the resulting increased stability is due to actual support of the pelvis on the upper end of the osteotomized femur. Consequently, in order to insure the optimum support, considerable attention has been directed to a discussion of the exact site of pelvic abutment, or of the angle at which the femoral shaft is to be osteotomized. A still more lively controversy has developed concerning the respective merits of the high, versus the low osteotomy.

Some surgeons prefer the Lorenz bifurcation, or the Hass modification of this operation. For others, the Schanz osteotomy is the procedure of choice, because there appears to be less postoperative disability following this operation than after either of the other two. Although each of these operations can restore stability to the unstable hip, each may also result unfavorably, largely because of undue interference with hip motion. Study of a large series of these cases led to the conclusion that, in each of these operations, the important factor responsible for the limitation of hip motion was the excessive angle (postosteotomy angle) formed by the femoral shaft with a line drawn from the femoral head to the upper end of the osteotomized shaft of the femur.

Attention was first called to the problem during the course of a check-up on the results of cases in which the bifurcation operation of

* Received for publication on December 26, 1940.

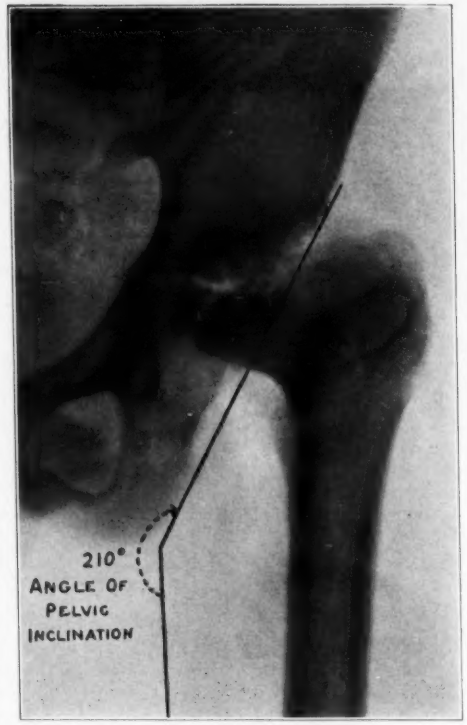

FIG. 1-A

Before operation. The femoral head is compressed and is only partly in the well-formed acetabular cavity. The angle of pelvic inclination shown by the drawn lines is equal to about 210 degrees. The intertuberosity distance between the ischial tuberosity and the lesser trochanter is clearly seen.

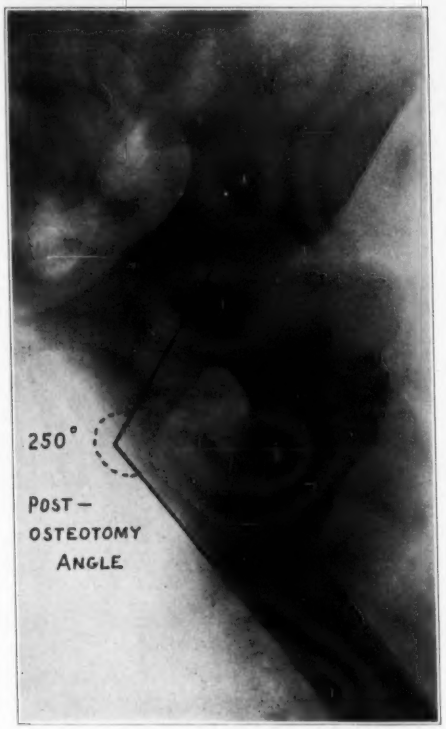

FIG. 1-B

A roentgenographically excellent bifurcation has been performed, but note, that as a result of the presence of the spike, the leg cannot be adducted. The postosteotomy angle, formed by the inner border of the shaft and the line drawn from the head to the tip of the spike, measures 250 degrees in a clockwise direction. The intertuberosity distance is obliterated.

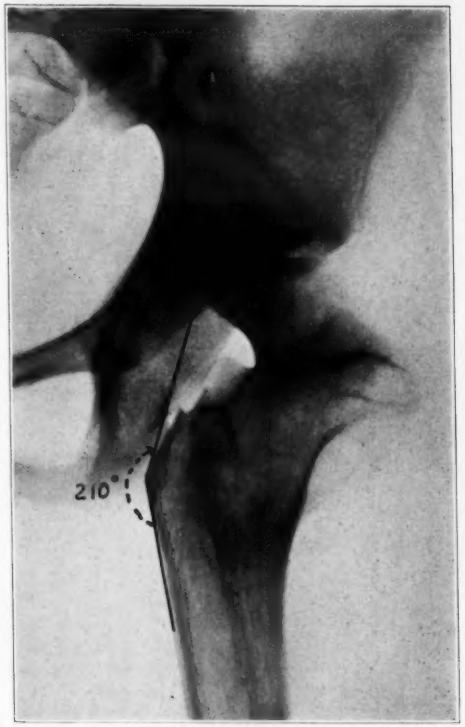

FIG. 1-C

Four years following operation. The spike has largely disappeared. As a result of this, the leg is in only slight abduction. The postosteotomy angle has been reduced to 210 degrees.

Lorenz or Hass had been performed bilaterally. Paradoxically, it was found that the roentgenographically "satisfactory" bifurcations almost invariably resulted in marked disability of a definite type.

Pain was present in varying degree. In some, the pain was so mild that it was overlooked in the satisfaction at the restoration of stability. In others, it was so severe that the patients insisted on relief. There was always an annoying increase in the intercrural distance, with an inability to bring the legs into parallelism. The patients could not completely flex or adduct the thighs. In the seated position they could not cross their legs, tailor-fashion. They could not assume the squatting position, and had difficulty in putting on their shoes and stockings. In the erect position, they stood with the legs abducted and the feet everted. Forward progress was possible only with a peculiar twisting and waddling gait, despite the fact that the Trendelenburg sign was usually negative.

On the other hand, and notably in children, it was observed that as the prong of the shaft fragment disappeared on the roentgenograms, the pain and disability vanished, usually without loss of the stability. This is typically illustrated in the following case.

S. O., a male, was first treated in 1923. When six weeks of age, a diagnosis of congenital dislocation of the left femur and congenital club-foot was made. When he began to walk he limped. The left hip was reduced by closed manipulation, but the child continued to limp. In 1932, an examination disclosed limitation of abduction and internal rotation, telescoping, and a shortening of the left, lower extremity. The roentgenogram (Fig. 1-A) revealed a marked deformity of the subluxated femoral head (traumatic epiphysitis). The acetabulum was fairly well developed.

On April 19, 1934, a typical bifurcation operation was performed, and a plaster-of-Paris spica was applied. Roentgenographically, it was believed that an excellent result had been obtained (Fig. 1-B). The well-formed prong of the lower fragment abutted against the anterolateral ischial wall, at about the level of the lower rim of the acetabulum. But the leg was held in wide abduction, and though its significance was not appreciated, a line drawn from the femoral head to the upper end of the osteotomized femur made, with the shaft, a postosteotomy angle of more than 250 degrees. In July 1934 the plaster was removed, and the patient was sent to a convalescent home. Upon his return, the mother noted that the child still walked with a limp, and experienced difficulty in putting on his shoes.

However, these disabilities tended to disappear with the lapse of time. In 1936, flexion at the hip was limited to 95 degrees and internal rotation was possible to only 10 degrees beyond the neutral position. In 1939 flexion had increased to 80 degrees and adduction was possible to 30 degrees beyond the neutral position. In 1940 adduction had still further increased to 45 degrees. The mother noted that the patient had markedly improved. The limp was only slight, there was no pain or discomfort, and the patient could cross his legs or put on his shoes without difficulty. The roentgenogram (Fig. 1-C) disclosed the explanation,—the bifurcation spike had almost completely disappeared, and the upper end of the femur presented somewhat the appearance seen after a high Schanz osteotomy. With the pelvis level, the femur was almost parallel to the sagittal plane of the body. The line joining the femoral head to the upper end of the femoral shaft formed, with the axis of the femur, an angle which had been reduced to less than 210 degrees.

Such marked improvement, invariably observed in children following absorption of the bony prong, suggested that in adults, in whom disability

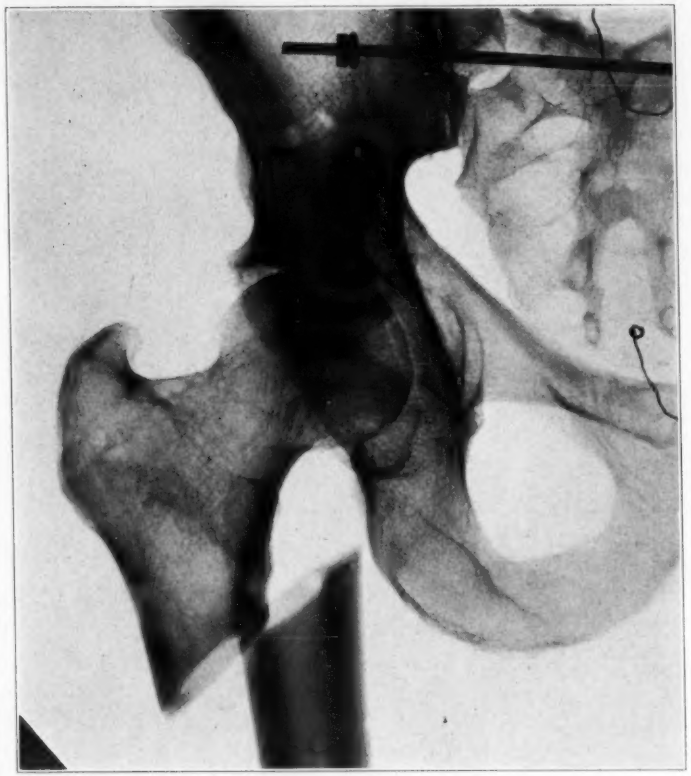

FIG. 2

The femur has been osteotomized, and the upper end of the distal fragment has been placed against the external ridge of the ischium. The leg is in an almost neutral position.

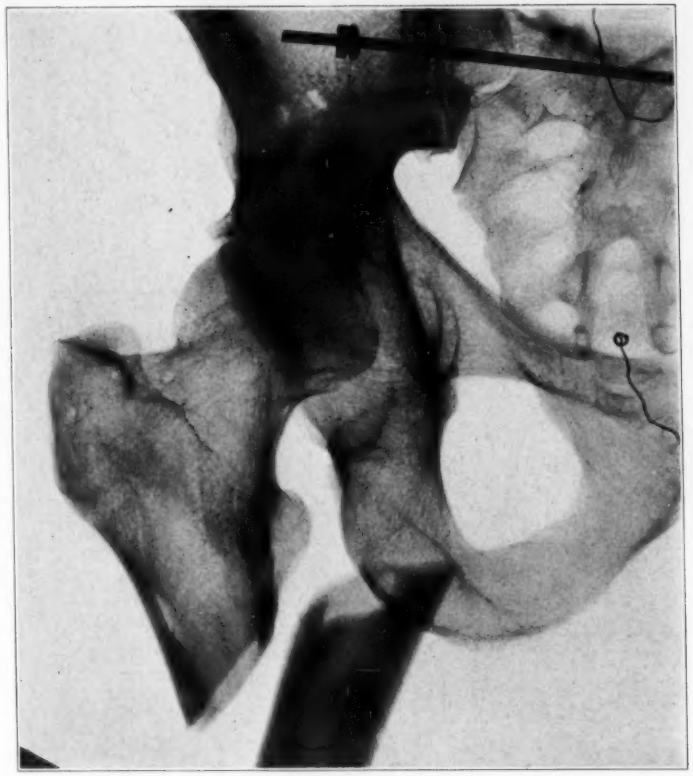

FIG. 3

The distal fragment has been slightly abducted, and the upper end of the spike has been directed forward.

persisted, similar relief might be obtained by surgical amputation of the offending spike of bone. Before this was undertaken, the action of the spike was studied directly on the skeleton. With the femoral head in the acetabulum, the shaft of the femur was cut in the plane of the Lorenz osteotomy and its upper end was displaced medially, without abduction, until it made contact with the pelvis, along the external border of the ischium. It was found that rotation was only slightly limited, but that flexion and adduction were moderately limited (Fig. 2). This was obviously caused by the impingement of the femoral shaft against the side of the pelvis. In effect, the intertuberosity distance, between the ischium and the lesser femoral trochanter, had been obliterated with resulting limitation of motion.

When the distal fragment was abducted and directed forward against the anterolateral wall of the ischium, so as to simulate the Hass modification of the Lorenz osteotomy (Fig. 3), it was noted that, with increasing abduction of the distal fragment, rotation, especially internal rotation, was proportionately diminished. When the upper end of the osteotomized fragment was directed backward against the posterolateral surface of the ischium, limitation of flexion, adduction, and especially external rotation, resulted. Invariably it was observed that the interference with motion was due to the impingement of the spike against the lateral projection of the ischial tuberosity.

The reason for this becomes clear when the pelvic girdle is examined. Due to the posterior interposition of the sacrum, the os innominatum is set obliquely into the pelvic ring. In consequence of its forward and inward direction, the body of the ischium presents an external border, which separates its anterolateral surface from its posterolateral surface, including the tuberosity. The external ischial border, together with the posterior rim of the acetabulum, forms a ridge, which, except for the flare of the ilium, presents the most lateral projection of the pelvis. The ridge is always visible on the roentgenogram, and, with the sagittal plane of the pelvis, affords a measure of the angle of inclination of the outer pelvic wall (Fig. 4). It is apparent, therefore, that when the osteotomized shaft makes contact with the pelvis, at any point other than along this ridge, the point of contact must lie medial to the ridge, and must lead to interference with rotation when the femoral head is fixed.

The head of the femur was then dislocated posteriorly onto the ilium, and the same experiments were repeated. Essentially, the same results, with one exception, were obtained. When the osteotomized shaft was displaced into the acetabulum according to the described technique of the operations, the most marked limitation in all arcs of motion was obtained. This was immediately recognized as being caused by the steeply sloping walls of the acetabular cavity, which, like the ridge, acted to obstruct the motion of the spike (Fig. 5). This observation is of especial significance, because of the expressed opinion that "the osteotomy is merely the preparatory step in the [bifurcation] operation. The

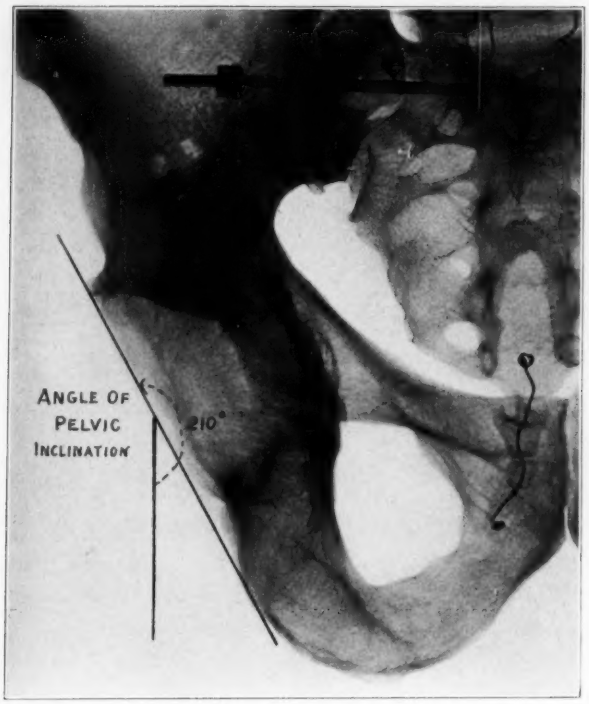

FIG. 4

On the roentgenogram, the outermost contour of the pelvis is determined by the external ridge of the ischium and the posterior rim of the acetabulum. With the sagittal plane of the body, this line makes an angle of about 210 degrees, which will be called the angle of inclination of the outer pelvic wall.

essential act is the reposition of the distal fragment into the acetabulum"[2]. Quite the contrary, it was found that, in the presence of a femoral head and neck, the acetabular position of the distal fragment was the worst of all the sites of pelvic abutment, and that the consequent limitation of motion could only be overcome by resection of the spike (Fig. 6). However, when the femoral head and neck were amputated, the acetabular position of the fragment acted to restore good balance and stability, without limitation of motion. Though this outcome could have been predicted from the principle that simultaneous, universal motion about each of two separate point fulcra is impossible in three-dimensional space, the studies demonstrated conclusively that the acetabular position of the bifurcation spike is to be avoided, except in those conditions in which the instability results from a pathological loss of the head and neck.

From these experiments, it appeared reasonable to conclude that the spike itself was the cause of the disability which these patients presented, and with some slight misgivings, the first patient was re-operated upon for resection of the projecting spike. The improvement was sufficiently encouraging to warrant other such attempts. The results of the first of these efforts have been reported elsewhere[5]. Briefly recapitulated, they indicated that stability could be preserved, despite removal of the spike. Pain disappeared immediately, and the range of hip motion was usually increased in proportion to the degree in which the bony projection was removed. But even complete amputation did not necessarily result in an invariably satisfactory outcome. In some cases, an almost normal range of motion was obtained. In others, the pelvic tilt noted in unilateral cases, persisted. This seemed to be due to excessive abduction

FIG. 6

The spike has been resected so that its upper end lies in the plane of the outer pelvic wall. The bone has been cut at the same angle, but the leg as a whole can be brought into greater adduction than in Fig. 5.

FIG. 5

The femoral head has been dislocated, and the spike is in the acetabulum. The leg is in marked abduction.

of the distal fragment, and clearly indicated the necessity for removal of the apex of the osseous angle projecting medially at the site of osteotomy.

This was performed with satisfactory outcome in the following case:

Frieda S., aged fifty-five, was first seen in the Out-Patient Department in January 1936. She had been in an automobile accident the previous summer, and walked with the aid of a cane, holding the knee, hip, and trunk flexed. The left thigh was externally rotated. Extension at the hip was limited to 150 degrees, and flexion to 85 degrees. Roentgenograms taken at this time showed a traumatic dislocation of the femoral head with numerous free fragments of bone in the soft tissues about the hip from a comminuted fracture of the margins of the acetabulum. Admission to the hospital for an operation to restore stability was advised.

On January 30, 1936, a bifurcation osteotomy in the sagittal plane was performed. The operation was carried out expeditiously, and the postoperative convalescence was uneventful. In September of 1936 the patient was able to stand without the aid of crutches. A mild degree of valgus of the knee was noted. In December 1936, the patient walked about without the aid of crutches. The roentgenographic report in 1937 stated, "excellent osteotomy, with the upper end of the distal fragment located at the lower quadrant of the acetabulum, in neutral position".

Re-examination in June, 1939, disclosed that the patient still walked with a slight limp and a waddle, but the Trendelenburg sign was negative. In the erect position the foot was held in the neutral position. Flexion was possible to a right angle, extension to 180 degrees, internal rotation to 15 degrees, external rotation to 60 degrees, abduction to 60 degrees. Despite this excellent arc of mobility in the erect position, the patient was unable to cross her legs, tailor-fashion, or, when seated, to put on her shoes without difficulty.

The roentgenogram (Fig. 7-A) showed a marked anteversion of the femoral head with an osteotomy of the high Schanz type. Careful examination of the plate disclosed an overlap of the shadows cast by the osteotomy angle and the body of the ischium. The impression was obtained that the apex of the osteotomy angle impinged against the ischium, in front of the external ridge, and so tended to restrict internal rotation. This was, of course, due to the relative shortening of the femoral neck, caused by external rotation of the upper fragment.

In effect, the intertuberosity distance had been reduced by a mechanism somewhat different from that seen in Figure 2. That this patient had a relatively good range of motion in the erect position, with limitation in the seated position, suggested the explanation that in the standing position the excessive angulation could be easily compensated for by tilting the pelvis, while in the seated position this became impossible, and a limitation of motion, not otherwise annoying, was brought to light.

The indication was obviously to re-osteotomize the femur, for the purpose of reducing the excessive abduction. The patient, however, refused to submit to any operation that would necessitate immobilization in plaster of Paris. To overcome this objection, it was decided to resect the apex of the bony angle. The patient was readmitted to the hospital and operated upon February 27, 1940. With the patient under anaesthesia, the range of motion was again tested. However, even then, with both legs held parallel, internal rotation was impossible beyond the neutral position. Through an anterior approach, using the descending arm of the Smith-Petersen incision, the site of osteotomy was exposed. The upper end of the femur presented a peculiar spiral twist from below, and medially to upward, outward, and backward. The upper fragment was obviously flexed, and, in addition, was excessively adducted, so that an angle, of which the apex pointed forward and inward, was formed. When an effort was made to adduct and internally rotate the leg, it was clearly seen that the angle of the osteotomy abutted

FIG. 7-A

Osteotomy performed for a traumatic dislocation of the femur. Note that the apex of osteotomy angle overlaps the shadow of the ischium, though the postosteotomy angle is about equal to the angle of inclination of the outer wall of the pelvis, the forward rotation of the neck has resulted in relative shortening of the neck, so that the osteotomy angle is displaced medially.

FIG. 7-B

Postoperative. The apex of the angle has been resected and the postosteotomy angle is about equivalent to that of the inclination of the outer pelvic wall.

against the pelvis and prevented rotation. The medially projecting portion of this angle was resected in the sagittal plane, and the wound was closed in the usual manner, without drainage and without plaster immobilization. Immediately after operation it was noted that internal rotation was possible to 25 degrees beyond the mid-line.

Within a week of her operation the patient was permitted to bear weight. No loss of stability was apparent, and the patient observed that there was a marked improvement in the range of motion. She was able to bend down to put on her shoes, and was able to cross her legs in the seated position. The roentgenogram (Fig. 7-B) showed that the angle of the osteotomized femur had been reduced, so that it was about equivalent to the angle of inclination of the outer pelvic wall.

This case proved of especial interest, because it demonstrated the essential identity of the effects produced by the bony spike of the Lorenz operation and the projecting bony angle typical of excessive abduction or flexion in the Schanz operation. It established the fact that the block which these bony prominences caused was due to excessive abduction of the distal fragment, and could be readily eliminated. The only question which remained was the determination of the amount of bone which had to be removed in order to insure restoration of motion.

When stated in this form, the question appeared to be one which could be answered only by the slow accumulation of individual experiences. However, if the question were the determination of the degree to which the distal femoral fragment can be abducted without limitation of motion at the hip, the problem seemed much simpler of solution. In his original contribution, Schanz pointed out that hip stabilization resulted from the application of the pelvis against the femoral shaft. Consequently, for practical purposes, the angle of *abduction* of the distal fragment in relation to the proximal fragment has been taken to be about equal to the degree to which the affected limb can be *adducted* when the pelvis is level. But at best this is only a rough approximation to the desired optimal angulation. From what has gone before, it is clear that, to a large extent, the result obtained will depend upon the exact point at which the femur makes contact with the pelvis. Even presuming that this site could be predetermined with any assurance, it can be readily shown that at any given point, the angle of abduction will vary considerably with the level at which the osteotomy is performed. It is in all probability the uncertainty introduced by these variable factors which accounts for Gaenslen's observation, "Some limitation of motion is not unusual, especially in flexion and adduction, but this is less than that following the bifurcation operation. . . ."

Since this limitation of motion is due to bony impingement of the femur against the pelvis, it is obvious that the postosteotomy angulation of the femur must not exceed the normal angle of inclination of the outer wall of the level pelvis. In this determination, the relationship of the distal to the proximal portions of the femur plays only a secondary rôle. The important part is played by what has been called the postosteotomy angle,—that is, the angle formed by the shaft and a line uniting the femoral head to the upper end of the distal fragment.

This can be readily demonstrated by the following considerations:

The normal femur is a hockey-stick-shaped structure which may be schematically represented by a triangle. The shaft, or anatomical axis, forms the outer boundary, the anatomical neck forms the upper boundary, and the mechanical axis, displaced by the medial projection of the neck, forms the inner boundary (Fig. 8-A). The important fact to stress is that the femoral neck which may be defined as the connection between the femoral head and the upper end of the shaft is directed medially, and that as a result the angle of the femoral neck opens medially and is less than two right angles.

Now, the function of femoral osteotomy is to change the line of weight-bearing stresses. This is accomplished by abduction of the distal fragment with reversal of the normal relationship of the femoral axes. As the abduction increases, the medially placed mechanical axis shifts outward, so that ultimately it comes to lie lateral to the anatomical axis. Progressively, the normal angle of the femoral neck increases to a straight angle, and ultimately to an angle which opens *laterally* instead of *medially*. In other words, the direction of the effective femoral neck has been reversed so that it, too, points laterally. The original anatomical neck remains unaltered, but a new neck, which consists of the anatomical neck plus that portion of the shaft proximal to the osteotomy, has been formed. This fragment as a whole constitutes the effective femoral neck, and the line which connects the femoral head with the upper end of the osteotomized femur forms what may be called, by analogy, the mechanical neck of the femur (Fig. 8-B).

This concept of the mechanical neck of the femur acquires additional significance when an effort is made to analyze the action of a Lorenz type of osteotomy. Here the upper end of the distal fragment is displaced upward, with the result that the mechanical femoral neck lies at some distance above the effective femoral neck (Fig. 8-C). It is the line joining the head to the upper end of the distal fragment—the mechanical neck of the femur—which forms, with the shaft, an angle whose importance has been overlooked. This angle, which has been called the postosteotomy angle, must be carefully differentiated from the angle of abduction at the site of osteotomy.

It is this postosteotomy angle, rather than the abduction angle between the proximal and distal portions of the osteotomized femur, that is of critical significance. In the simple abduction osteotomies, the postosteotomy angle normally increases proportionately with the angle of abduction. In the Lorenz osteotomy, however, the postosteotomy angle can be increased to any given amount by simple upward displacement of the distal fragment without any corresponding increase in the abduction angle (Fig. 8-C). This being the case, it is apparent that regardless of the degree of abduction, it is the postosteotomy angle which must be controlled. Since the apex of this angle is directed medially, it is clear that this angle must not be permitted to exceed the angle of inclination

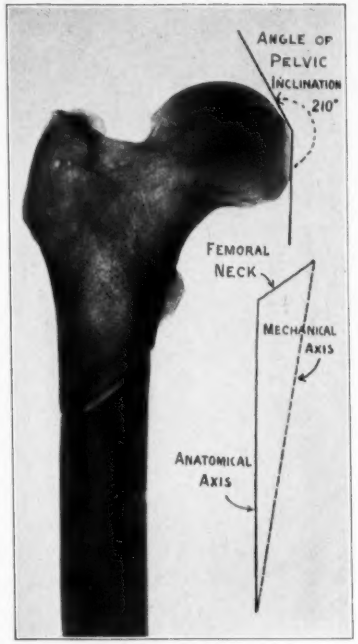

FIG. 8-A

The normal femur may be schematically represented as a triangle. The anatomical neck forms the upper boundary, the anatomical axis or shaft the outer boundary, and the mechanical axis the medial boundary. The neck is directed medially, and the angle of the femoral neck, less than two right angles, opens medially.

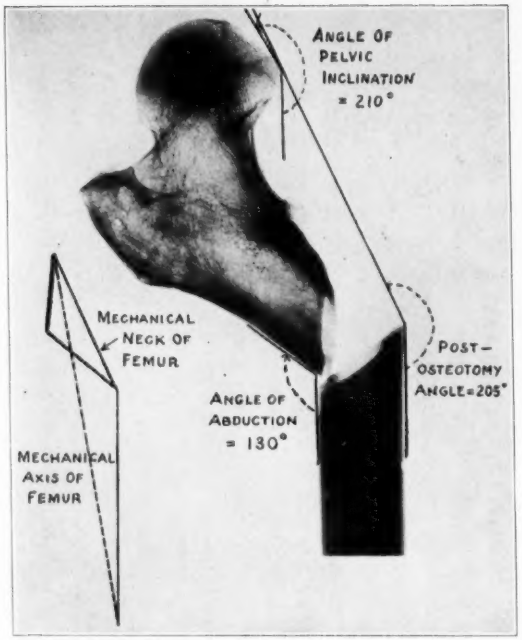

FIG. 8-B

Osteotomy of the Schanz type creates a new femoral neck, consisting of the anatomical neck and the proximal portion of the osteotomized shaft. For the purpose of this illustration, the appearance of the Schanz osteotomy has been simulated by opening a wedge on the inner side, instead of removing a wedge from the outer side. The upper fragment, directed outward, constitutes a new *mechanical* neck of the femur, which, with the shaft, makes the postosteotomy angle larger than two right angles, and opening *outward*. This angle is equal to 205 degrees and is less than the angle of pelvic inclination of 210 degrees. The mechanical axis has shifted from the medial to the lateral side of the femur.

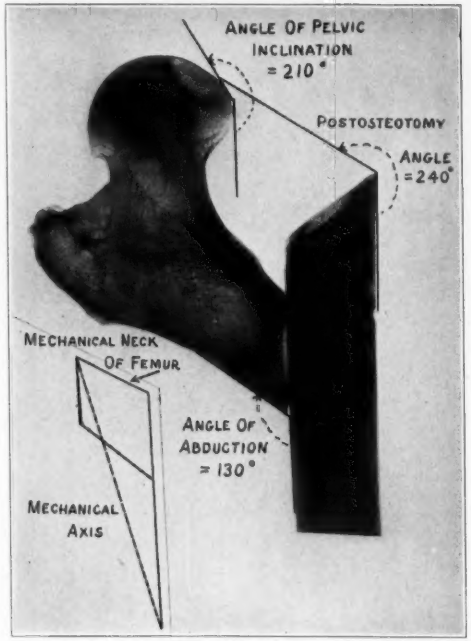

FIG. 8-C

Osteotomy of the Lorenz type displaces the mechanical neck of the femur above the effective femoral neck. As compared with Fig. 8-B, the angle of abduction is identical, but the postosteotomy angle has been increased to 240 degrees. The intertuberosity space has been eliminated. To avoid limitation of motion the spike must be resected so that the postosteotomy angle is less than 210 degrees, or the angle of pelvic inclination must be increased by pelvic tilt so that it is greater than 240 degrees.

of the outer pelvic wall. If this does occur, in the coronal plane, normal parallelism of the legs is impossible, and both adduction and rotation are impeded. If it occurs in the sagittal plane, as by excessive flexion of the proximal fragment, flexion of the leg is limited.

Since the degree of stability of the hip increases with the lateral displacement of the mechanical axis, there has been a natural tendency to increase the abduction of the distal fragment so as to achieve the maximum shift. In unilateral cases, abduction of as much as 45 degrees, and even 60 degrees, have been suggested. In the erect position, the excessive postosteotomy angle, which such abduction determines, can be readily compensated by a tilting of the pelvis, which in effect increases the angle of pelvic inclination. (This of course presupposes the possibility of a corresponding adduction of the opposite leg, so as to permit parallelism in normal progression.)

It was the consideration of this point which furnished the clue to the whole problem. Where pelvic tilting was limited, from whatever cause, or where parallelism of the legs was impossible, limitation of motion necessarily resulted. In bilateral cases, in which excessive postosteotomy angles were formed, adduction of the opposite leg was limited, and adequate compensatory tilting of the pelvis was impossible. In the seated position, where also pelvic tilting was impossible, the large postosteotomy angle similarly hampered the patients in crossing their legs or in putting on their shoes. Clearly, the indication was the reduction of the postosteotomy angle so that it was equal to, or preferably less than, the angle of pelvic inclination. By actual measurements on the roentgenograms, this angle varies between 210 and 230 degrees, and experience indicates that the postosteotomy angle should, in general, not exceed the lower figure.

Once this concept became clearly defined, its general validity in all types of upper femoral osteotomy seemed apparent. When it was applied to the consideration of the Lorenz bifurcation, a very interesting observation was made. In principle, the Lorenz bifurcation consists of two separate steps: (1) the abduction osteotomy, and (2) the upward displacement of the distal fragment. The function of the first of these elements has already been discussed. Strange though it may seem, the action of the second is directly to overcome the effects accomplished during the first stage. It can readily be demonstrated that the upward displacement tends to decrease both the stability and the range of motion which results from abduction.

During its first, or abduction phase, the Lorenz bifurcation presents essentially the same mechanical picture as the Schanz osteotomy. Abduction of the distal fragment has resulted in lateral shifting of the mechanical axis, so that stability is increased. The postosteotomy angle has been increased, and, for the sake of the argument, it will be assumed that it has been increased to the point where the maximum of stability without limitation of motion has been achieved. At this point, the pelvis

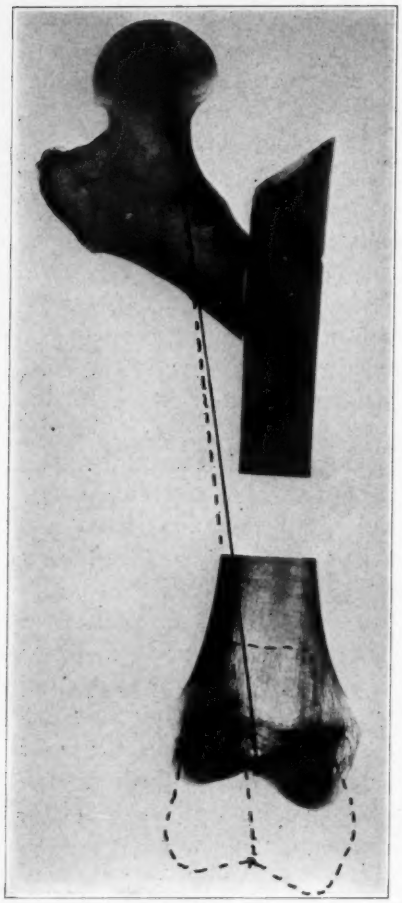

FIG. 9

Osteotomy of the Lorenz type shifts the mechanical neck of the femur upward, with consequent increase of the postosteotomy angle to much beyond the angle of pelvic inclination, as in Fig. 8-C. In the simple abduction osteotomies, increase in this angle is associated with a corresponding lateral shift of the mechanical axis and increased stability. However, because of femoral shortening, the mechanical axis is here shifted more medially, with relative decrease in stability for any given degree of abduction.

is still level and the legs are parallel. Now the second phase of the operation is performed. Maintaining the same degree of abduction, the distal fragment is displaced upward, until contact with the pelvis takes place. Promptly thereafter, limitation of adduction, rotation, and even flexion, occur. Clinical observations and experimental study amply establish the fact that this is due to projection of the bony spike formed by the upper end of the osteotomized shaft. It could be hoped that, for the resulting loss of motion, a proportionate increase in stability might be achieved. But exactly the opposite occurs.

From a mechanical point of view, the upward displacement of the shaft acts to shift the mechanical neck of the femur upward, and so to increase the size of the postosteotomy angle. In all other osteotomies, the increase in this angle necessarily implies a *lateral* shifting of the mechanical axis and a tendency to increase stability. In the Lorenz osteotomy, because of the shortening of the femur as a whole, the mechanical axis moves *medially*, and, for the same angle of abduction, tends to *diminish* the stability. It is only by further increasing the abduction, and so decreasing the mobility, that the stability previously obtained can be preserved (Fig. 8-C).

The observations here made in regard to the Lorenz operation apply with even greater force to the operative modification suggested by Hass. In his operation, the upper end of the distal fragment is displaced forward, as well as inward. The flexion of the proximal fragment, combined with this forward inclination of the upper end of the distal fragment, tends to yield that degree of excessive anterior angulation to which Gaenslen called attention in discussing the Schanz osteotomy. It appears that, whatever the angle may be, the formation of a spike tends to defeat the purpose for which it was devised.

For any desired degree of stability, the spike imposes the necessity of greater abduction and the assurance of limitation of motion. For any desired degree of mobility, it imposes the necessity of decreased angulation with the assurance of diminished stability. In fact, its greatest field of usefulness seems to be precisely in those conditions, such as tuberculous coxitis, in which limitation of motion may be desirable.

The therapeutic implications of these considerations are immediate. The formation of a spike should be avoided. The osteotomy should be performed in the plane of the anatomical neck of the femur. The angle of abduction of the distal fragment of the femur should be such that the post-osteotomy angle is less than the angle of pelvic-wall inclination. These elements in the successful performance of femoral osteotomy impose the necessity of careful control of the osteotomized fragments. For this reason, exposure of the femur through an anterior incision, careful execution of the osteotomy, and subsequent control of the fragments by plaster or by pins incorporated in the plaster, seems advisable. Postoperative roentgenograms with actual measurement of the postosteotomy angle are imperative in determining the need for increasing or decreasing the angulation of the distal fragment.

If the patient is seen some time after union of the osteotomy has occurred, and disability persists, revision of the operation should be advised. Whenever possible, the spike, if present, should be amputated. Where the angulation is not too great, the apex of osteotomy may be resected sufficiently to reduce the angle to below that of the pelvic wall. However, if the angulation is so great that simple resection cannot be safely carried out, osteotomy and reduction of the degree of abduction must be performed.

REFERENCES

1. GAENSLEN, F. J.: The Schanz Subtrochanteric Osteotomy for Irreducible Dislocation of the Hip. J. Bone and Joint Surg., XVII, 76, 1935.
2. HASS, JULIUS: Zur Technik der Lorenzschen Bifurkation. (Die schräg frontale Osteotomie.) Ztschr. f. Orthop. Chir., XLIII, 481, 1924.
3. LANCE, PIERRE-MARIE: Les ostéotomies sous-trochantérienne dans le traitement des luxations congénitales invétérées de la hanche. Paris, Masson & Cie, 1936.
4. LORENZ, ADOLF: Ueber die Behandlung der irreponiblen angeborenen Hüftluxationen und der Schenkelhalspseudoarthrosen mittels Gabelung (Bifurkation des oberen Femurendes). Wiener klin. Wchnschr., XXXII, 997, 1919.
5. MILCH, HENRY: Bifurcation Operation. Surgery, VIII, 686, 1940.
6. SCHANZ, A.: Zur Behandlung der veralteten angeborenen Hüftverrenkung. Münchener med. Wchnschr., LXIX, 930, 1922.

THE USE OF NEOARSPHENAMINE IN THE TREATMENT OF ACUTE STAPHYLOCOCCUS AUREUS SEPTICAEMIA AND OSTEOMYELITIS *

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The use of arsenic compounds in the treatment of staphylococcus aureus septicaemia was first attempted by the authors in 1932. At that time an acute osteomyelitis of the femur had developed in a girl, as a complication to an acute empyema and suppurative pericarditis. The blood culture revealed the staphylococcus aureus to be the offending organism. It was suggested that neosalvarsan, which had been used with good results in pyelitis due to staphylococcus aureus infection, might be beneficial. The drug was used and a recovery effected. The infected femur was, of course, drained and treated according to accepted methods.

Following this experience, Dr. D. H. Nickson made some laboratory tests to determine the effect of arsenic compounds on the staphylococcus aureus in culture. It was found that, on test plates, growth of the staphylococcus aureus was inhibited in 1:100 dilutions of neosalvarsan; dilutions of 1:100 up to 1:1000 retarded growth, but did not inhibit it; and dilutions greater than 1:1000 had no effect on the organism.

During the last eight years, all cases of acute osteomyelitis have been treated on the assumption that a septicaemia caused by staphylococcus aureus existed. Early surgery, when not contra-indicated, has been carried out. The blood culture has been made in the operating room, and the first dose of arsenic has been given on the operating table. If the blood culture showed no growth, no further use of arsenic was made. If the blood culture was positive, arsenic was continued over a period of some days.

The following is a comparison of the results which have been obtained by the use of neoarsphenamine with results obtained prior to its use.

The number of records examined was 131, of which sixty-six were selected. The arbitrary basis for this selection was that no patient whose record was summarized had a temperature of less than 101 degrees on admission, had an illness of prolonged duration, or one that was an exacerbation of a chronic osteomyelitic infection. In other words, only the acute, fulminating types of infection were considered. There were forty-four males and twenty-two females. The average age in years was eight and one-half. The average duration of the symptoms was six days. The average temperature on admission was 103.2 degrees, or 104 degrees rectal temperature.

The location of the disease in this series followed the usual course, the tibia and the femur being the most usual locations of the infection.

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, New Orleans, Louisiana, January 14, 1941.

Of the sixty-six patients selected for this study, fifty-three had blood cultures made, while thirteen did not. This laxity in the making of blood cultures may be partially explained by the fact that the series of cases runs back to 1927, or thirteen years. Of the cultures of the fifty-three patients for whom blood cultures were made, thirty were found to be positive and twenty-three negative.

No patient having a negative blood culture died, whereas there were thirteen deaths in the group with positive blood cultures. Twenty-three, or 100 per cent., of the patients with negative blood cultures recovered. In the group with positive blood cultures, seventeen patients recovered. In other words, in this group of fifty-three patients for whom blood cultures were made, there were forty recoveries and thirteen deaths.

To come back to the use of arsenic in the treatment of acute staphylococcus aureus septicaemia and osteomyelitis, this drug has been of great benefit in reducing the rate of mortality. In recent studies Osgood, of the University of Oregon Medical School, has conducted extensive research on the effectiveness of neoarsphenamine, sulfathiazol, sulfanilamide, and sulfapyridine in the therapy of staphylococcus aureus infections in marrow cultures. He has shown that sulfathiazol and sulfamethylthiazol in dilutions of 1:10,000 are definitely inferior to neoarsphenamine in dilutions of 1:150,000 to 1:200,000 in destroying the staphylococcus aureus in marrow cultures.

Of the thirty patients who showed positive blood cultures, twenty-one received neoarsphenamine; of these, five, or 24 per cent., died and sixteen, or 76 per cent., recovered. Of the nine who received no neoarsphenamine, eight, or 89 per cent. died, and one, or 11 per cent., recovered.

Dosages used have been more or less empirical. The routine has been to administer an initial dose of 0.15 grams, and to increase the dose gradually every three days to a maximum of 0.45 grams. In no case have more than seven doses of the drug been administered.

According to Osgood's recent work the dosage should be: body weight in pounds divided by 330; this indicates the total dose to be given on the first day in three or four divided doses. Each subsequent day three-fourths of this dose is administered, divided into three spaced doses, and this is carried on until the patient has been afebrile for six to ten days.

CONCLUSIONS

Neoarsphenamine is a powerful weapon in combating septicaemia and acute osteomyelitis due to the staphylococcus aureus. The death rate has been markedly decreased through its use. It is hoped that the drug may find wide general use and be subjected to further clinical study.

REFERENCES

LeCocq, Edward: The Use of Neosalvarsan in the Treatment of Acute Osteomyelitis. Western J. Surg. Gynec. Obstet. XLIV, 655, 1936.

Osgood, E. E.; Joski, Julia; Brownlee, I. E.: The Superiority of Neoarsphenamine and Sulfathiazol in the Therapy of Staphylococcus Aureus Infections in Marrow Cultures. Surg. Gynec. Obstet. LXXI, 445, 1940.

THE TIMING OF THE FRACTURE-HEALING PROCESS

Its Influence on the Choice and Application of Treatment Methods*

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Based upon the intensive research of the last quarter century into the nature of the tissue reaction following fracture, the author is of the opinion that there is today a reasonably clear idea of what takes place, although the whys and the hows are still in many respects hazy or unknown. He believes that one may accept as reasonably certain, on the basis of both experimental and clinical evidence, the following as the probable course of events in the "average" or "normal" case:

1. Tissue death and hemorrhage in both soft parts and bone as result of trauma. This is immediate.

2. The reaction of inflammation secondary to the autolytic products of tissue death and hemorrhage into the tissues,—the outpouring of inflammatory exudate, and the stagnation and engorgement of the local minute circulation in tissue spaces, lymphatics, and ultimate capillaries. This occurs in a space of hours.

3. The creation of a markedly lowered pH in the local tissue fluids by these products of tissue death and hemorrhage, until such time as the local minute circulation can disperse them.

4. The formation of a fibrin network by the clotting of hemorrhage and exudate.

5. The progressive decalcification of bone as long as it lies in tissue fluids of a markedly low or acid pH.

6. The appearance and growth of undifferentiated connective-tissue cells along the fibrin network joining the bone ends and surrounding tissues. This can be seen as early as twenty-four to thirty-six hours after injury.

7. The accumulation of unprecipitated or undeposited calcium in some undetermined form in this tissue network, apparently in connection with the fibrin of clot and the collagen of the undifferentiated new tissue. This starts as early as the fibrin formation and continues as long as the dual condition of local calcium accumulation and the presence of collagen or fibrin in a low or acid pH exists.

8. Gradual rise of the local tissue fluid pH from the acid level by reason of the dispersion of the autolyzed products of tissue death and the products of local tissue metabolism by increasingly efficient local minute circulation.

*Read before the American Academy of Othopaedic Surgeons, New Orleans, Louisiana, January 15, 1941.

9. Deposition of the accumulated calcium in the newly formed undifferentiated tissue. There is sufficient evidence to support strongly the supposition that this occurs when the pH of the local tissue fluids has risen to a point where a phosphatase can become active. This is callus formation.

10. There is adequate support for the viewpoint that, if the new tissue becomes differentiated into adult formed connective tissue before the pH of the tissue fluids has risen to a point where phosphatase activity is possible, no calcium deposition occurs. A so-called fibrous union takes place instead. If the pH rises to a point which allows only minimal phosphatase activity, a slow calcium deposition occurs, but ceases as a local healing process when tissue differentiation is complete.

It is obvious that chronological time in this story means little or nothing save as an "average" figure, because of wide variations in the severity and extent of tissue damage, and of anatomical factors which affect the speed of progress of the pathological process. "Time" refers to the stage of progress which the pathological condition has reached. It is to be interpreted in terms of clinical evidence,—such as the character and extent of swelling, pain, tenderness, oedema, infiltration, and ecchymosis. The stage of progress which is reached at the end of eight hours in the "average" case may be reached or passed in two hours in a severe case, or may not be attained for twelve, sixteen, or twenty-four hours in others less severe or differently situated. But the actual place in "time" of each of these cases is definitely proclaimed to careful examination by the patient's signs and symptoms. The logical rule to follow is to treat the fracture in accordance with the pathology present, regardless of chronological time elapsed since injury, by modifying whatever method the surgeon is best capable of handling effectively. A standard treatment applied early in point of pathological progress may be eminently successful, and as eminently unsuccessful if applied late; the reverse of this is also often true. The difference in significance of the terms "early" and "late" does not mean a question of weeks, or for that matter even days, but may have to be interpreted in terms of a very few hours.

This brief résumé of a viewpoint is necessary to consider how treatment may affect the timing and progress of this process, or, conversely, how treatment may have to be modified according to the stage at which treatment is undertaken. It is obviously impossible to enter into a prolonged discussion of the viewpoint itself in this paper. However, an annotated bibliography which covers the pros and cons of the problem both from the academic and the clinical side is appended.

It is proposed to illustrate the influence of the timing of the process on the choice of method, and on the manner of carrying out the chosen method, by citing clinical conclusions which have been reached on a Service where the technique of treatment has been developed for the last twelve and a half years on the basis of the expected effect on the pathological situation present at the time of treatment. The conclusions are

drawn from the clinical results obtained by treatment methods and technique developed on this principle in something over 13,000 fracture cases.

1. The "time" schedule of the development of tissue reaction after fracture dictates the technique of traction-suspension as a method of treatment. Reduction, in so far as length is concerned, should be attained within a few hours. The author likes to get it in four hours. Every effort should certainly be made to get it within the twelve-hour period. The underlying principle is to get the normal length while the muscles are still elastic and can be stretched without damage and with minimum effort. Depending upon the severity of the trauma this elasticity is lost in from four to sixteen hours, and stretching of the muscle can then no longer occur. The muscle is infiltrated with hemorrhage, exudate, and fibrin, and is subject to the laws of hydraulics rather than to those of elastic bodies. The common failing is to underpull in these early hours for fear of overpull. It is freely stated by some that overpull cannot be corrected, and persists if allowed to remain more than a very short time. This statement is erroneous. Overpull can be corrected readily, even if it has existed for several hours, provided it is corrected before the "congealing" of the musculature makes correction impossible. It is proper to say that it is difficult or impossible to correct if it has been in effect overnight, or if it has been applied *after* the muscle infiltration is advanced. Because of this misconception, overpull at any time is warned against. What is lost sight of is the fact that once the pathological state is fully established, underpull is as hard to correct as is overpull, and the too common conception of traction-suspension, skeletal or otherwise, as a method of *reduction* acting over days or weeks is responsible for some of the reputation which traction-suspension bears as a factor in the etiology of delayed union and non-union. As a method of *maintaining a reduction* it can of course be used for any period of time. Fractures seen twelve or more hours after injury are not ideal subjects for traction-suspension. For that matter, they are not ideal subjects for any method of treatment. It must be remembered that whatever method of reduction is used in these late cases must add additional pathology to get length, if the fracture site lies in muscle bellies already congealed. If traction-suspension is used in these cases, overpull must be carefully guarded against.

2. A fracture which is to have an open reduction is best done within four to eight hours after injury,—before the infiltration process has reached the point of being "fixed" in the tissues. During such an early operation the escape of blood and exudate from the tissues leads to minimal soft-part pathology with its functional implications, and, logically, on the basis of the conception of the healing process described above, to more certain and quicker calcification of the healing tissue to form callus. The author is firmly convinced by careful study of clinical results that this is actually so. He is also firmly convinced, on the basis of actual statistical analysis, that the risk of operative infection is less in these

early-hour operations than in those done at any other time within the first week after injury.

3. The least satisfactory time for open reduction on a recent fracture is from about the twelfth to the twenty-eighth day, during which time maximum decalcification of the bone in the vicinity of the fracture is occurring, and any internal fixation must be made in bone which may be incapable of taking the strain.

4. Recent fractures treated by open reduction followed by plaster immobilization take longer for bone healing than similar cases treated by closed methods. This clinical observation is thoroughly in keeping with the relative stagnation of the local minute circulation which results from immobilization of the soft parts as well as of the bone.

5. Early (emergency) operation, with internal fixation rigid and firm enough to allow of active mobilization postoperatively in counter-balanced suspension, not only restores joint and muscle function more promptly than is possible in immobilized patients, but promotes the speed and certainty of fracture healing. This it does by allowing the escape of a great deal of pathological material at operation, and by greatly increasing the effectiveness of the local minute circulation (tissue spaces, lymphatics, and ultimate capillaries) in dealing with what remains behind. The active functioning of muscles without spasm, such as can be obtained with properly applied and supervised balanced suspension after adequate operative fixation, is one of the most effective means at our disposal for the stimulation of such circulation.

6. In general the open reduction of fractures followed by plaster immobilization results in prolongation of the time needed for bone healing as compared with similar cases treated by closed methods. This is particularly true when the operation is done some days after healing. On the pathological process already "fixed" in the tissues, is superimposed the damage resulting from operative trauma, and the subsequent immobilization minimizes the efficiency of the local minute circulation which has to cope with the accumulation of products tending to defeat the adequate formation of callus. This has been the author's experience, and it could not logically be otherwise in the light of the strikingly definite findings under the preceding observation.

7. If examination of the roentgenograms leads to the conclusion that internal fixation, rigid enough to allow active mobilization of the extremity postoperatively in balanced suspension, will not be possible, the patient is best treated by closed methods if possible. This is but a natural corollary of observations 5 and 6. Operation on such a patient should be by virtue of necessity only. If he has to be operated upon, the earlier the operation the better, provided it is in the first two weeks.

8. If fixation is not rigid, and if it does not provide protection against torsional, sheering, and angular forces, absorption of bone about the fixation material will occur. When external immobilization of the extremity is added to the internal fixation of the fracture, these forces may

be guarded against in part or almost in whole at the expense of functional activity of the part, with all its implications.

9. On the basis of some of the points mentioned above, it is obvious that the principles of "reduction as soon after injury as possible" is applicable to *all methods of reduction.* It is questionable, however, as to whether or not this general rule holds true for fractures so situated that the question of progressive pathological change in muscle is not a factor, such as fractures involving the ankle joint (particularly when the inferior tibiofibular joint has been disrupted), fractures involving the wrist joint, and fractures of the os calcis. While it is unquestionably true that these fractures are best reduced within the first six to eight hours, it is also true that if they are first seen twelve or twenty-four hours after injury with enormous swelling (with or without bleb formation), not only is reduction at that time difficult, but adequate fixation in plaster is either difficult or impossible because of the tremendous soft-part swelling. Since no pathological condition exists in the muscles in these cases, with the exception of muscle spasm as a protective mechanism, is it not justified to devote twenty-four or forty-eight hours, not more, to an intensive attack on the soft-part swelling, so that reduction is more easily accomplished, more accurately gauged, and more readily and effectively maintained by external immobilization? Through the use of moderate elevation, constant low-grade heat, gentle stroking massage, the use of the positive and negative pressure boot, and such other methods as are at our disposal, the minute circulation can be speeded up and the tissue infiltration decreased. This is a far cry from "waiting for the swelling to go down" since it is actually an intensive attempt to disperse the tissue infiltration. It is getting rid of pathology, instead of allowing it to organize in the tissues. In this respect, and in the fact that such delay in reduction for a very limited time is applicable only to late cases with the pathology already established, and in which muscle is not involved in the pathological condition, it differs materially from John Royal Moore's delayed reduction practice.

10. Fractures involving certain portions of the body have been noted for their tendency to either excessive callus formation or actual ossification in the adjacent soft parts. This tendency is, of course, particularly marked in fractures, with or without dislocation, in which the anterior portion of the elbow joint capsule and the overlying brachialis anticus have been involved. This tendency can be prognosticated in many cases by the clinical examination which discloses signs of damage to the deep anterior structures with infiltration of the antecubital region, tension beneath the forearm fascia, and even direct antecubital ecchymosis within an hour or two of fracture, and by the anterior displacement of separated bone fragments. The abnormal bone formation occurs only if the pathological process is allowed to progress to its maximum. Operative or vigorous manipulative procedures after this time are apt to increase the tendency to bone formation. Relief of the soft-part pathology

in the early hours is the safeguard against this complication, whether it be accomplished by operation or otherwise. But recognition of the necessity for that relief is the crux of the situation.

It is the author's belief that our undergraduates can derive more sound understanding of the basic principles which underlie fracture treatment as a whole, if they come to think more about what any method of treatment has to accomplish in the guiding of the pathological process after fracture, and less about the technical details of treatment methods. The ability to interpret physical signs as indicative of the pathological state present, and of the speed with which it is progressing is a sound basis for the intelligent use of any method of treatment.

BIBLIOGRAPHY

1. GIRDLESTONE, G. R.: The Response of Bone to Stress. Proc. Royal Soc. Med., XXVI, 55 (Section of Orthopaedics, p. 1), 1932.
   Defense of osteoblast as specific cell. Discussion of internal and external architecture of bone in reference to stress and strain incident to injury and disease.
2. JAFFE, H. L.: The Structure of Bone with Particular Reference to Its Fibrillar Nature and the Relation of Function to Internal Architecture. Arch. Surg., XIX, 24, 1929.
   On the structure of bone and a challenge to the truth of Wolff's law.
3. CARY, E. J.; ZEIT, WALTER; AND MCGRATH, B. F.: Studies in the Dynamics of Histogenesis. XII. The Regeneration of the Patellae of Dogs. Anat. Record, XXXV, 6, 1927.
   On dynamics of histogenesis in bone.
4. HAM, A. W.: A Histological Study of the Early Phases of Bone Repair. J. Bone and Joint Surg., XII, 827, Oct. 1930.
   Defense of the specificity of the osteoblast, and against metaplasic origin. In favor of osteoblast as origin of both bone and cartilage.
5. KEITH, ARTHUR: Concerning Origin and Nature of Osteoblasts. Proc. Royal Soc. Med., XXI, 301 (Section of Surgery, p. 1), 1927.
   Defense of the specificity of the osteoblast and of its metaplasic origin when needed.
6. MAYER, LEO, AND WEHNER, ERNST: An Experimental Study of Osteogenesis. Am. J. Orthop. Surg., XII, 213, Oct. 1914.
   In defense of the specific osteoblast *per se* or by metaplasia, and of their presence normally in endosteum and periosteum. Against any specificity in the "bone cell" (non-peripheral cells in lacunae of trabeculae). Advocates the idea of a definite osteogenic layer of the periosteum and specific calcium-depositing cells.
7. NEUHOF, HAROLD: Fascia Transplantation into Visceral Defects. An Experimental and Clinical Study. Surg. Gynec. Obstet., XXIV, 383, 1917.
   On the extraskeletal formation of bone (in bladder and gastric fascial and fat transplants). In favor of metaplasia, and pro osteoblastic in viewpoint.
8. ROHDE, CARL: Does Bone Form from Osteoblasts or from a Metaplasia of the Surrounding Connective Tissue? Surg. Gynec. Obstet., XLI, 740, 1925.
   Is opposed to metaplasia, and strongly in favor of specific osteoblasts. Explains heteroplasia as derived from embryonal undifferentiated mesodermal rests.
9. BLAISDELL, F. E., AND COWAN, J. F.: Healing of Simple Fractures. An Experimental Study. Arch. Surg., XII, 619, 1926.

Discusses metaplasic origin of cells involved, the periosteum's active rôle in osteogenesis, and the functional specificity of osteoblasts and osteoclasts, all from the affirmative side.

10. GREIG, D. M.: Clinical Observations on the Surgical Pathology of Bone. Edinburgh, Oliver and Boyd, 1931.

Against specific osteoblast, and for biochemical non-cellular activity.

11. FELL, H. B.: Chondrogenesis in Cultures of Endosteum. Proc. Royal Soc. London (B), CXII, 417, 1933.

Against the primary specific osteoblast, proponent of metaplasia viewed as a differentiation of an embryonal (new fibroblast) element. Discusses concurrent cartilage and bone formation in the same fibroblastic nidus from this standpoint.

12. BANCROFT, F. W.: The Process of Bone Repair Following Trauma. Am. J. Med. Sciences, CXLVII, 809, 1914.

The Use of Small Bone Transplants in Bridging a Bone Defect. Ann. Surg., LXVII, 457, 1918.

The above references advocate a metaplasic origin of the cellular elements, but stress the local biochemical state and the clinical implications thereof.

13. MURRAY, C. R.: The Modern Conception of Bone Formation and Its Relation to Surgery. J. Dental Research, XI, 837, 1931.

Against the specific osteoblast of any origin, in defense of the local biochemical status as a basic factor, and an exposition of the relationship between surgical pathology and treatment indications.

14. LERICHE, R., AND POLICARD, A.: The Normal and Pathological Physiology of Bone; Its Problems. (Translated from the French by Sherwood Moore and J. A. Key.) St. Louis, C. V. Mosby Co., 1928.

Presents to some degree the pros and cons of all sides of the story, but in the main is against specific osteoblast, favors in the main the idea of metaplasia, and has interesting suggestions as to the origin of the bone matrix or osteoid.

15. HOWLAND, J.: The Etiology and Pathogenesis of Rickets. Medicine, II, 349, 1923.

On mechanism of calcium deposition. Interesting in relation to the central ossification in osteoid trabeculae although osteoblasts lie peripherally placed.

16. MURRAY, C. R., AND MURRAY, M. R.: The Mechanism of Deposition of Calcium to Form Extraskeletal Bone in the Adult Animal—a Preliminary Study. Anat. Record, XLVII, 292, 1930.

On mechanism of calcium deposition; is opposed to specific cell activity; in favor of factor of environmental biochemistry, particularly interrelation of pH conditions and ferment activity of non-specific origin, as a basic one.

17. HARRIS, H. A.: Bone Formation and the Osteoblast. Lancet, II, 489, 1928.

Discusses the chemistry of calcification with a strong defense of osteoblastic specific function and metaplasic origin of the osteoblast.

18. KIRBY, D. B.: A Study of Calcium in Relation to Cataract. Trans. Am. Acad. Ophthal., XXXV, 154, 1930.

On the ophthalmological problem of cataract formation, but provides an interesting discussion of the mechanism of local calcium concentrations.

19. WELLS, H. G.: Pathological Calcifications. J. Med. Research, XIV, 491, 1906.

On the chemistry of calcification.

20. WATT, J. C.: The Deposition of Calcium Phosphate and Calcium Carbonate in Bone and in Areas of Calcification. Arch. Surg., X, 983, 1925.

On the chemistry of calcification and in favor of chemical-precipitation theory.

21. WELLS, H. G.: Calcification and Ossification. Arch. Int. Med., VII, 721, 1911.

On the physicochemical basis of calcification.

22. Cowan, J. F.: Non-Union of Fractures. An Experimental and Clinical Study. Ann. Surg., LXXXVIII, 749, 1928.
On the intrinsically local nature of the fracture-healing process.
23. Campbell, W. C.: Ununited Fractures. Arch. Surg., XXIV, 990, 1932.
Discussion of the physical factors involved in fracture repair, and in bone-grafting.
24. Murray, C. R.: The Repair of Fractures. Minnesota Med., XIII, 137, 1930.
On the purely local nature of fracture healing, including the question of the calcium utilized in the formation of callus; in support of the tissue-fluid biochemistry as a basic factor, as opposed to specific cell activity as a factor; and against the osteoblast viewpoint.
25. Phemister, D. B.: The Recognition of Dead Bone Based on Pathological and X-Ray Studies. Ann. Surg., LXXII, 466, 1920.
Aseptic necrosis and replacement of dead bone following bone injury; the conception of "creeping replacement".
26. Tisdall, F. F., and Harris, R. I.: Calcium and Phosphorus Metabolism in Patients with Fractures. J. Am. Med. Assn., LXXIX, 884, 1922.
In favor of correlation between fracture healing and general calcium and phosphorus metabolism.
27. Ravdin, I. S., and Jonas, Leon: Studies of Calcium and Phosphorus Metabolism in the Fracture of Bones. Ann. Surg., LXXXIV, 37, 1926.
Against correlation between fracture healing and general calcium and phosphorus metabolism.
28. McKeown, R. M.; Lindsay, M. K.; Harvey, S. C.; and Howes, E. L.: The Breaking Strength of Healing Fractured Fibulae of Rats. II. Observations on a Standard Diet. Arch. Surg., XXIV, 458, 1932.
29. McKeown, R. M.; Lindsay, M. K.; Harvey, S. C.; and Lumsden, R. W.: The Breaking Strength of Healing Fractured Fibulae of Rats. III. Observations on a High Fat Diet. Arch. Surg. XXV, 467, 1932.
IV. Observations on a High Carbohydrate Diet. Arch. Surg., XXV, 722, 1932.
The above references deal with the influence of general metabolism deficiencies on fracture healing, ascribing to them an important rôle.
30. Brown, W. L., and Brown, C. P.: Preliminary Report on Experimental Bone and Periosteal Transplantation. Surg. Gynec. Obstet., XVII, 681, 1913.
A denial of a periosteal rôle in ossification.
31. Fell, H. B.: The Osteogenic Capacity *in vitro* of Periosteum and Endosteum Isolated from the Limb Skeleton of Fowl Embryos and Young Chicks. J. Anat., LXVI, 157, Jan. 1932.
On osteogenesis in young embryos from young and old endosteum and from young periosteum, but not from old periosteum.
32. Haas, S. L.: The Importance of the Periosteum and the Endosteum in the Repair of Transplanted Bone. Arch. Surg., VIII, 535, 1924.
On the necessity of preservation of both periosteum and endosteum in bone transplants with arguments in favor of both being bone-forming structures.
33. Girdlestone, G. R.: The Treatment of Fractures in the Light of Their Ischaemic Complications. J. Bone and Joint Surg., XIV, 755, Oct. 1932.
On the factor of ischaemia in relation to bone repair; a discussion of vascular circulatory factors.
34. Morton, J. J., and Stabins, S. J.: Circulatory Factors Influencing Normal Osteogenesis. Ann. Surg., LXXXVI, 430, 1927.
On the relationship between gross venous stasis and fracture healing.
35. Johnson, R. W.: A Physiological Study of the Blood Supply of the Diaphysis. J. Bone and Joint Surg., IX, 153, Jan. 1927.
On the influence of vascular conditions in bone repair and fracture healing.

36. KAY, H. D.: The Function of Phosphatase in Bone-Formation. British J. Exper. Path., VII, 177, 1926.

On the significance and function of phosphatase in bone formation.

37. FELL, H. B., AND ROBISON, ROBERT: The Growth, Development and Phosphatase Activity of Embryonic Avian Femora and Limb-Buds Cultivated *in vitro*. Biochem. J., XXIII, 767, 1929.

The Development and Phosphatase Activity *in vivo* and *in vitro* of the Mandibular Skeletal Tissue of the Embryonic Fowl. Biochem. J., XXIV, 1905, 1930.

38. GOODWIN, H. W., AND ROBISON, ROBERT: The Possible Significance of Hexose-Phosphoric Esters in Ossification. Part IV. The Phosphoric Esters of the Blood. Preliminary Communication. Biochem. J., XVIII, 1161, 1924.

39. KAY, H. D.: Kidney Phosphatase. Biochem. J., XX, 791, 1926.

The above references are on the development of phosphatase and its activity.

40. BANCROFT, F. W.: Bone Repair Following Injury and Infection. Arch. Surg., V, 646, 1922.

On the clinical implications of tissue biochemistry in relation to fracture treatment and bone-grafting.

41. MURRAY, C. R.: Delayed and Non-Union in Fractures in the Adult. Ann. Surg., XCIII, 961, 1931.

On the clinical implications of the non-osteoblastic conception in regard to the prevention and treatment of delayed union and non-union.

42. MURRAY, C. R.: Healing of Fractures. Its Influence on the Choice of Methods of Treatment. Arch. Surg., XXIX, 446, 1934.

On the clinical implications in treatment of fractures, and in the fate of bone grafts in modern studies of bone repair. In support of the non-osteoblastic viewpoint.

43. LINDSAY, M. K., AND HOWES, E. L.: The Breaking Strength of Healing Fractures. J. Bone and Joint Surg., XIII, 491, July 1931.

Discussion of breaking strength during healing; an intermediate period of decreased breaking strength between primary healing and eventual reconstruction—of considerable clinical interest.

44. BALLIN, MAX: Parathyroidism. Ann. Surg., XCVI, 649, 1932.

On the rôle of the parathyroid. Presents the pro-parathyroid argument.

45. CHANDLER, S. B.: The Healing Fractures in Parathyroidectomized Albino Rats. Anat. Record, XXXV, 7, 1927.

On the rôle of the parathyroid. Presents the anti-parathyroid argument.

46. LEHMAN, E. P., AND COLE, W. H.: Parathyroid Hormone and the Calcification of Fracture Callus. J. Am. Med. Assn., LXXXIX, 587, 1927.

On the influence of the parathyroid; a viewpoint that it not only does not aid fracture healing, but may actually afford interference.

47. ROSS, D. E.: Relation of the Parathyroids to the Healing of a Fracture as Controlled by the Roentgen Rays. Arch. Surg., XVI, 922, 1928.

On the parathyroid influence; in favor of influence of severe parathyroidism as deterrent to fracture healing, and against mild parathyroidism as a factor of any clinical importance.

48. THOMPSON, R. L., AND SWARTS, J. L.: The Influence of the Thyroid and Parathyroid Glands on the Healing of Fractures. J. Am. Med. Assn., LVII, 724, 1911.

Against the influence of thyroid in fracture healing.

PHYSIOLOGICAL SCOLIOSIS *

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This introductory study of the pathology and the therapy of scoliosis was undertaken in the hope that the results obtained would also be of definite value in the treatment of paralytic scoliosis. It was carried out in the Orthopaedic Department of the State University of Iowa, and the author gratefully acknowledges the interest and support accorded him by Dr. Arthur Steindler, the Head of this Department.

Prior to its recognition by anatomists and other investigators, the existence of physiological scoliosis had been constantly observed by tailors and dressmakers for many centuries, of course without their having recognized the condition. As the physiological scoliosis increased with advancing age, the tailor or dressmaker would become suddenly aware that the shoulders of the customer were no longer level and that one of the hips had become prominent. The whole stature of the individual had changed, and it would become necessary to camouflage the usual physiological deformation ascribed to age. The main reason for the change was nothing but physiological scoliosis, which, by shifting of the shoulder girdle from one side of the hip line to the other, had finally changed the stature.

The existence of physiological scoliosis was scientifically established over 150 years ago by Sabatier, who found that the great majority of adult spines showed a well-defined curve to the side; in the lumbar and cervicothoracic segments the convexity was usually to the left side, and in the thoracic region, to the right side.

The investigation of physiological scoliosis in cadavera and in living persons in large-scale clinical examinations has been mainly concerned with the lateral curve; the form of the curve and the direction of the convexity have been amply described. Most investigators agree upon the existence of the phenomenon, but some of prominence (notably Lorenz) deny it. In the author's opinion, the examination of cadavera or even of living persons can hardly prove or disprove the existence of physiological scoliosis. The reasons for this are obvious:

1. The position of the cadaver is always an arbitrary one, depending on the will of the investigator, especially in cases of *slight* abnormality.

2. In living persons the clinical investigation must take into account the to some extent arbitrary posture of the individual, his tendency toward autocorrection, and the difference in the length of the legs.

3. The routine roentgenographic examination is made with the

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patient in the supine position; hence the author has found that the great majority of roentgenograms of the spine (especially of young persons), taken for other purposes, do not display much evidence of a lateral curve. It is well known that in cases of scoliosis slight lateral curves, and even more marked ones, completely disappear in the supine position.

4. In the standing position, lateral curves may be easily effaced by the counteraction of the *healthy* intervertebral discs, which, due to the large amount of their elasticity, do not allow the development of lateral curves for a long period, even in pathological scoliosis. Thus the demonstration of the spine without discs presents the lateral curves in an exaggerated form, as compared with the living individual, but it represents the deformation of the vertebrae in its true aspect.

In previous papers the author has repeatedly referred to the well-defined deformations found in normal vertebrae, as well as to the cause of these phenomena, but he has not included a detailed analysis. For this purpose, in the present study twenty complete normal skeletons, ranging from nineteen to eighty-six years of age, were examined. Besides these, the skeleton of a normal six-year-old child and that of a seriously deformed scoliotic child were examined and measured, serving as standard types of normality and scoliotic deformation with which the skeletons of normal adults were compared.

The examinations were concerned exclusively with the invariable element of the spine,—that is, with the vertebrae. The postmortem shrinking and the preparation of the ligamentous apparatus interfere with the true happenings, and the author tried to avoid any arbitrary factor in the investigations.

The examination of the cervical spine was omitted, as in this region scoliosis very rarely occurs. For mechanical and developmental reasons not to be discussed here, the author divided the spine into three functional segments:

I: The upper thoracic, comprising the first six thoracic vertebrae;

II: The lower thoracic, consisting of the remaining six thoracic vertebrae plus the first lumbar vertebra;

III: The lumbar, including the lower four lumbar vertebrae.

The twelve thoracic and the five lumbar vertebrae were examined with reference to the following factors:

1. The alignment of the spine when hung on a wire;

2. The height of the vertebral body on its left and right sides, measured at the level anterior to the attachments of the ribs and the roots of the pedicles;

3. The length of the pedicles (the distance between the posterior edge of the vertebra and the superior articular process);

4. The greatest width of the dorsal surface of the pedicles;

5. The length of the dorsal surface of the vertebral body on its right and left sides (the distance of the posterior border of the body from its anterior border);

6. The angle between the impressio cordalis vertebrae * and the spinous process on each side;

7. The angle between the impressio cordalis vertebrae and the transverse process on each side;

8. The angle between the impressio cordalis vertebrae and the inferior articular processes of the lumbar vertebrae and of the eleventh and twelfth thoracic vertebrae.

The measurements were made by means of an anthropometer and a goniometer (Fig. 1).† The choice of the mold on the back of the vertebral body (impressio cordalis) as the center for the measurements of the angles was motivated by the fact that it is the spinal cord which preserves its position best in any deformation of the vertebrae. In the case of the spinous and transverse processes, the center of measurement was the end of the process. On the basis of the measurements, graphs, representing the behavior of the seventeen vertebrae measured, were drawn.

TERMINOLOGY

In order to avoid confusion, the author wishes to clarify the following terminology used in this paper:

1. *Neutral vertebrae* are those which do not show any obvious signs of deformation, having the normal shape customarily depicted in the textbooks of anatomy. They are called "neutral" instead of "normal" because either below them or above them, or both below them and above them the vertebrae are deformed. Thus they belong neither to the one class nor to the other class of deformed vertebrae within a deformed spine.

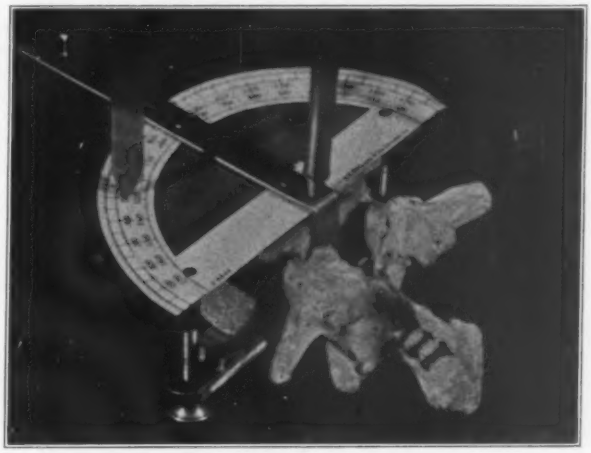


FIG. 1

Device for the measurement of the angles between the vertebral body and the spinous process, the transverse process, and the inferior articular processes.

2. *Rhombic, lozenge-shaped, or transitional vertebrae* are those which have a conspicuous rhombic shape, but show little or no difference in height between their right and left sides. They give the impression that the upper surface of the vertebral body has shifted to one side, while the lower surface of the

* Posterior frontal surface of the vertebral body, the center of which is formed by the impression of the spinal cord.

† These instruments were designed by the author and constructed by Mr. A. P. Freund of the Physiology and Pharmacology Shop of the University.

same vertebrae has shifted to the opposite side. They connect one lateral curve, convex to one side, with another lateral curve, convex to the opposite side. Thus they represent a transitional zone in the course of changing curves.

3. *Wedge-shaped vertebrae* are those whose most striking feature is the diminishing of the height of the vertebral body on one side as though the vertebra had collapsed on one side, leaving the impression of a wedge. Wedging is the typical trait of the pathological scoliotic vertebrae in the center of the curve. Wedge-shaped vertebrae often are also rhombic to some extent, a phenomenon which has an important bearing on the development of scoliosis.

4. The *angles* represent the relationship between the sagittal plane and the frontal plane of the body. The perfectly normal spinous processes are in the sagittal plane, forming an angle of 90 degrees with the posterior surface of the vertebral body. The normal transverse processes of the middle thoracic region form an angle of 45 degrees with the posterior surface of the vertebral body. The normal inferior articular processes of the lumbar vertebrae form an angle of about 55 degrees with the posterior surface of the vertebral body.

5. The *elongation* is the lengthening of the upper surface of the right or left sides of the vertebral body; mechanically it is identical with the rhombic deformation. The rhombic deformation consists of the shifting of the entire upper surface of the vertebral body, while the elongation is the pulling out of only one side of the upper surface.

POSTNATAL DEVELOPMENT OF THE VERTEBRAE

Skeleton of Normal Six-Year-Old Child

At the age of six, the alignment of the spine was found perfectly straight; the physiological sagittal curves were completely developed. The vertebral bodies showed in all segments symmetric conditions. The height of the vertebral bodies was roughly the same on both sides, and there was no difference in the length of the upper surfaces of the vertebral bodies between the two sides. The asymmetric development of the pedicles in both dimensions had already started in Segment III.

The spinous processes were found exactly in the sagittal plane of the vertebral bodies, forming an angle of 90 degrees. The average value of the angle formed by the transverse processes in Segment I was 44 degrees, just 1 degree below the average found in adults. In Segment II the mean value of the angle formed by the transverse processes was 45 degrees; the transverse processes were perfectly symmetric on both sides. In Segment III the angle formed by the transverse processes was 29 degrees on the right side and 28 degrees on the left.

Skeleton of Severely Deformed Scoliotic Child

Examination of the other standard type—severe "habitual" scoliosis—showed the curves in the upper thoracic and lumbar segments convex

to the left; in the lower thoracic segment the curve was convex to the right (Fig. 2).

Every true scoliotic spine is composed of three kinds of vertebrae: *wedge-shaped, rhombic (lozenge-shaped or transitional)*, and *neutral*. The wedging plays the chief rôle in the production of the lateral curve, and is regarded as the principal feature of this deformation. In the opinion of the author, the pathological scoliotic deformation begins with the formation of lozenge-shaped vertebrae (*prescoliotic stage*), and the lateral wedging follows later. This can easily be demonstrated in the further development of pathological curves. The lozenge-shaped vertebrae connect one curve with the other, and they are the vertebrae which become involved in the scoliotic process while the deformation progresses. Later on, the newly involved lozenge-shaped vertebrae tilt and gradually become wedge-shaped. Therefore, in any scoliosis, except perhaps in the case of the most wedge-shaped vertebrae, the original rhombic character always can be deduced from the marked oblique course of the bone lamellae. The scoliotic curves are generally regarded as lateral curves. This seems to be a mistake to some extent. *There is no pure lateral curve in pathological scoliosis.* Perfect lateral curves are found in the rare cases of *contracture of the spine*, especially following infantile paralysis. The pathological scoliotic curves are not lateral curves, but take place between frontal and sagittal planes; they collapse in the oblique plane, representing a diagonal deformation of the spine.

FIG. 2

Spine of a scoliotic individual, showing collapse in the diagonal plane. The thoracic kyphosis has disappeared, and the lumbar lordosis has increased, due, in part, to subluxation of the articular processes. Many of the vertebrae have preserved their original rhombic (lozenge-shaped) form.

Another important point in pathological scoliosis is the behavior of the physiological sagittal curves. The com-

plete disappearance of the thoracic kyphosis and its replacement by lordosis (Fig. 2) are commonly observed. On the other hand, the lumbar lordosis, which, at the beginning of the process, especially in the "habitual" cases, frequently diminishes or disappears, becomes very often more marked in the course of the deformation, than in normal individuals.

The neural arches can resist the deforming forces much longer than the vertebral body, the latter being the first to be affected by the force of gravitation as well as by the pathological process leading to the deformity. That is why the spinous and transverse processes not only slowly follow

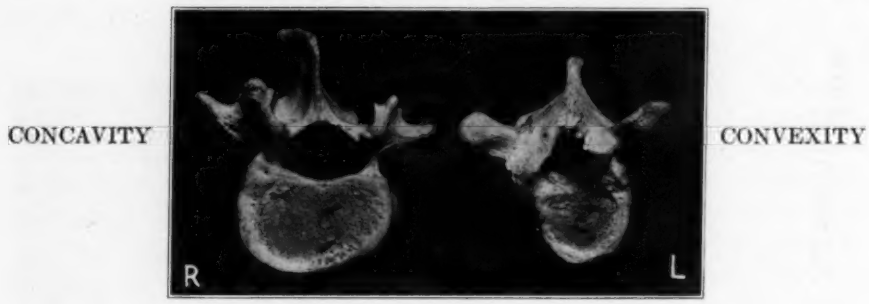


FIG. 3

Lozenge-shaped (transitional) vertebrae of a scoliotic spine. There is marked elongation to the right. The arches are definitely in the concavity of the curve, while the body has penetrated into the convexity.

the course of deformation but *remain definitely in the concavity throughout life* (Fig. 3). That is also why the vertebrae give the impression of rotation or torsion. In the author's opinion, there is very little true rotation of the thoracic vertebrae, even in pathological scoliosis; there is, rather, the delusion of rotation. The impression of rotation seems to be due simply to the fact that the bodies of the vertebrae have deviated to a much greater extent than have the neural arches. The resistance of the arches accounts also for the fact that the scoliotic deformation appears surprisingly less marked when the spinous processes are seen from the rear than when the vertebral bodies are viewed from the front. *Especially in the most important segment, Segment II, the deviation of the spinous processes was definitely opposite to that of the curve.* The transverse processes showed a great conformity in amount of, as well as in direction of, the deviation of the spinous processes. The pedicles behaved in all of the segments as they do in physiological scoliosis.

The deformation of the ribs seems to play but a minor rôle in physiological scoliosis; therefore, the discussion of this point is omitted here.

Skeletons of Twenty Normal Adults

In the twenty normal skeletons examined, there were no fundamental qualitative differences either between the age groups or between the sexes. It was noted that the amount of the lateral curves, the asymmetric

changes, and the osteophyte production increased with advancing age, although this seemed to be less marked in some instances than might have been expected.

Lateral Curves: In 80 per cent. of the specimens, the lateral curves were convex to the left in Segments I and III and to the right in Segment II. The number of vertebrae involved varied greatly in each specimen and in each curve, as compared with the others, and so did the amount of the curves. In some instances, very small lumbar curves were followed by sharp low-thoracic curves; in others the high-thoracic curve seemed to be effaced as compared with the other curves of the same specimen and with those of other specimens. In a few instances, only one long, sharp, low-thoracic curve was definitely present, while the lumbar and high-thoracic curves were only very slightly suggested. In the author's opinion, the percentage evaluation should be omitted, as the small series of only twenty specimens does not give sufficient evidence. In 20 per cent. of the specimens, an *inversion* of the lateral curves occurred. In these the lumbar and high-thoracic curves were convex to the right and the low-thoracic curve was convex to the left.

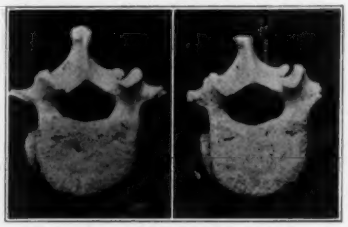
Elongation: Both the upper and the lower surfaces of the vertebral bodies became longer, pulled out on one side (Figs. 4-A, 4-B, and 4-C). In each specimen only a few vertebrae—most frequently in the high-thoracic and low-lumbar regions—failed to show this asymmetry. Generally, in the high-thoracic segment the vertebral bodies became elongated on the left side; in the low-thoracic segment, on the right side; and in the lumbar segment, on the left side. Exceptions to this rule were found in vertebrae belonging to spines which showed reverse curves (20 per cent. of the specimens).

Lateral Wedging: The further asymmetry consisted of the differences in height of the vertebrae between the right and left sides. This phenomenon, called "lateral wedging", revealed a very peculiar feature. In Segment I, none of the specimens showed vertebrae which were higher on the right side. In Segment II, only 15 per cent. of the vertebrae revealed a higher right side; 25 per cent. were higher on the left side; and 60 per cent. were level. In Segment III, 15 per cent. of the vertebrae were higher on the left side; 50 per cent. were higher on the right side; and 35 per cent. were level.

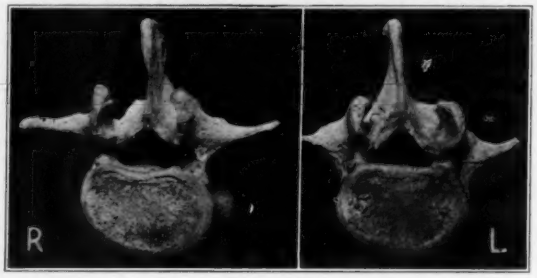
It was striking that in the most important segment, Segment II, more than half of the vertebrae showed no wedging; furthermore, almost twice as many of the vertebrae showed a greater height on the left side than on the right. This means that, in consideration of the fact that Segment II showed in 80 per cent. of the vertebrae a lateral curve convex to the right, in physiological scoliosis *the wedging has but little to do with the lateral curve;* otherwise, in 80 per cent. of the vertebrae the height of the vertebrae should have been found greater on the right side.

The contrasting behavior of the side of wedging and elongation on the one hand and the corresponding behavior of the side of elongation and

convexity of the curve on the other clearly demonstrate that *in physiological scoliosis the lateral curve is more intimately related to the elongation than to the wedging*, which is essentially opposite in the case of pathological scoliosis. As already pointed out, the chief feature of pathological scoliosis is that the height of the vertebral body on the convexity of the curve always exceeds that on the concavity, being exclusively responsible for the side to which the curve points.



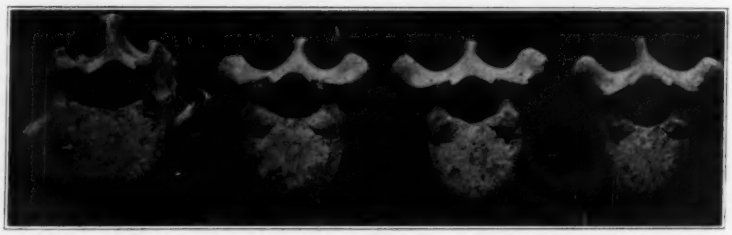
CHILD



ADULT

FIG. 4-A

Pedicles: None of the parts of the vertebra disclosed the asymmetric postnatal development to such an extent as did the pedicles (Fig. 5). The asymmetry can be noticed at the age of six, as already mentioned. The pedicle is the most sensitive segment of the vertebra, connecting as it does the vertebral body with the neural arch. Thus the pedicles, thin and relatively long, readily give evidence of the distort-



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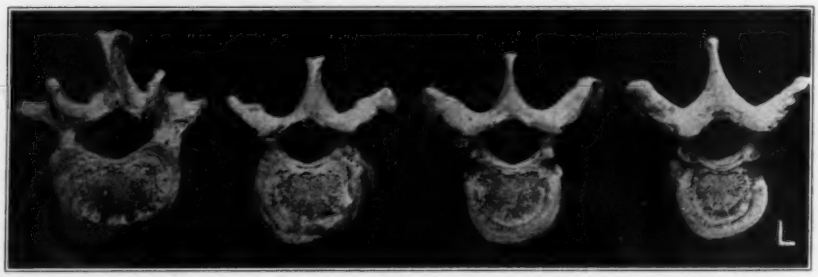
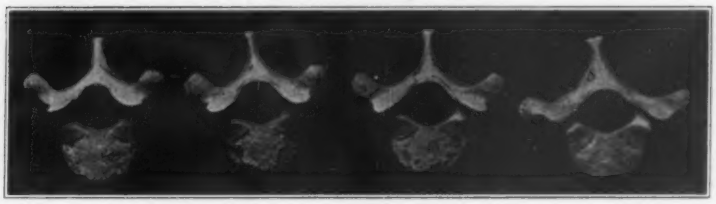


ADULT

FIG. 4-B



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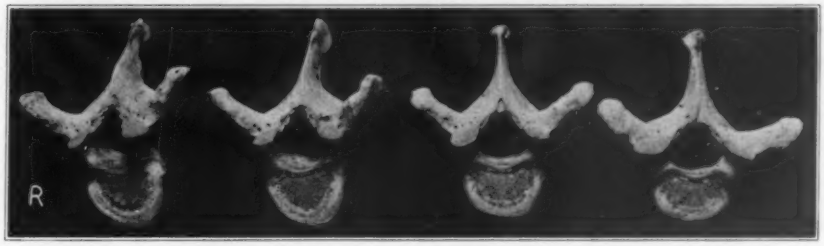

ADULT

FIG. 4-C

Vertebrae of a normal six-year-old child compared with those of a normal adult.
Fig. 4-A: Lumbar segment; elongation to left in adult.
Fig. 4-B: Lower thoracic segment; elongation to right in adult.
Fig. 4-C: Upper thoracic segment; elongation to left in adult.

ing forces. They become asymmetric earlier than the bulky vertebral bodies or the resistant neural arches. None of the pedicles were found without asymmetry after the age of six. Either their length or their width, but in most instances both, showed the physiological deformation. The variation in the length of the pedicles showed a greater regularity than that in their width. In most instances the width of the pedicles was in inverse relation to their length: they were long and thin or short and broad.

Spinous Processes: In Segment I the spinous processes deviated to the right side in the majority of the specimens; in Segment II they pointed to the left; and in Segment III they generally deviated to the right. The deviation of the spinous processes was frequently twofold: their roots pointed to one side, while their extremities pointed to the other side, or formed an angle of 90 degrees.

Transverse Processes: The behavior of the transverse processes differed greatly from that of the spinous processes. In Segment I they generally deviated to the left; in Segment II half pointed to the right and the other half to the left; and in Segment III the great majority deviated to the left.

An almost complete conformity was found between the behavior of the transverse processes and that of the inferior articular processes.

As to the angles between the transverse processes and the posterior surface of the vertebral body, in Segment I they amounted to 45 degrees at the age of six, and from then on they showed a marked regression to the

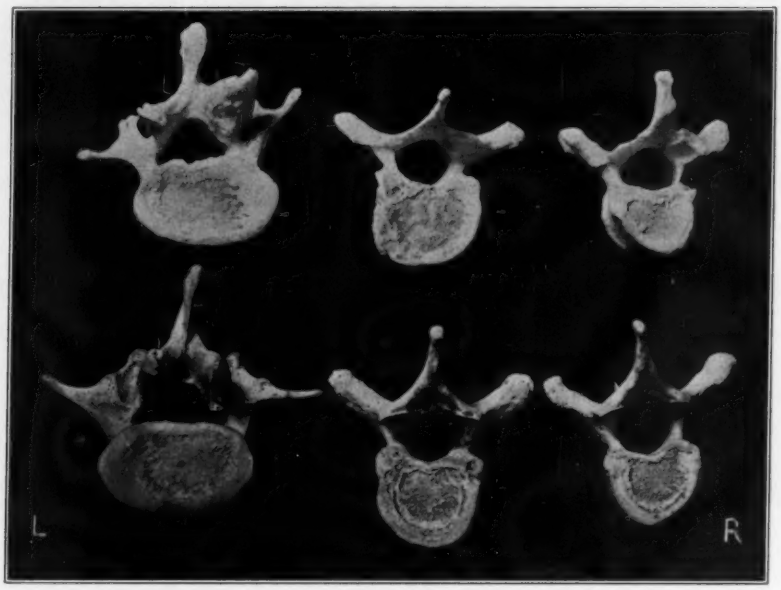

FIG. 5

Physiological deformation of the articular, spinous, and transverse processes and of the pedicles in a normal adult (lower row) as compared with similar deformity in a child with scoliosis (top).

mean value of 40 degrees in adults. In Segment II the 45-degree angle at the age of six seemed to be maintained throughout life. In Segment III the 28-degree angle at the age of six diminished to 26 degrees in the adults. The diminishment of the angles of the transverse processes was certainly caused by the development of physiological lordosis.

Ribs: The ribs were apparently of nearly the same shape and had the same angular value on both sides, in spite of the sometimes marked lateral curves of the spine.

COMMENT

The question arose whether or not the findings were due to: (1) the normal variation of the spine or (2) the normal postnatal development. As to the former, such a regularity of variation was found in all of the specimens examined, that it seemed obvious that a variation occurring always in the same or almost in the same way is no mere oscillation around a normal type, but it represents the normal features of the organ. As far as the question of the postnatal development determined by the germ is concerned, the fact that the vertebrae develop from symmetric ossification centers must be taken into account. There is no reason at all to assume that the two halves may develop in postnatal life in such a peculiar asymmetric manner. The vertebrae of the six-year-old child, although completely developed, were almost perfectly symmetric. The osteophyte production, intimately connected with the asymmetric behavior of the vertebrae, as will be demonstrated later, is the best argument for the as-

TABLE I

MEAN VALUES OF VERTEBRAL BODIES AND PEDICLES (IN MILLIMETERS) COMPUTED FROM TWENTY DIAGRAMS

Spinal Segment	Vertebral Body				Pedicles			
	Height (Wedging)		Length (Elongation)		Length		Width	
	Right	*Left*	*Right*	*Left*	*Right*	*Left*	*Right*	*Left*
I	17.8	18.0	21.8	22.7	11.0	9.6	6.0	5.6
II	21.7	21.9	32.0	30.0	13.3	12.6	6.5	6.3
III	25.5	26.0	32.3	32.4	10.5	9.7	10.0	11.2

sumption that *the postnatal regular asymmetric development of the human spine is due to some powerful, automatic function which becomes established just prior to the age of six.* The question of whether or not the phenomenon could be regarded as the consequence of the asymmetric course of the aorta which flattens the vertebrae on one side must be considered also. The beginning of the descending portion of the aorta is the lower border of the fourth thoracic vertebra, somewhat to the left. Its termination is in the mid-line of the lower border of the twelfth thoracic vertebra. However, the changes in the vertebral bodies concern the entire spinal column. The upper thoracic region, as well as the lumbar region, reveals the most impressive asymmetric changes just where the descending aorta is in no relation to the spine (upper thoracic and lumbar vertebrae) or has already reached the mid-line of the spine (lower thoracic vertebrae). Thus, *physiological scoliosis is a postnatal development, due neither to the regular variation of the normal, nor to the innate formative energy of the cells,*

TABLE II

MEAN VALUES OF ANGLES (IN DEGREES) COMPUTED FROM TWENTY DIAGRAMS

Spinal Segment	Angles					
	Spinous Processes and Vertebral Body		Transverse Processes and Vertebral Body		Articular Processes and Vertebral Body	
	Right	*Left*	*Right*	*Left*	*Right*	*Left*
I	88.0	92.0	40.5	38.5		
II	91.0	89.0	45.0	42.0		
III	90.0	90.0	26.0	26.0	55.0	53.0

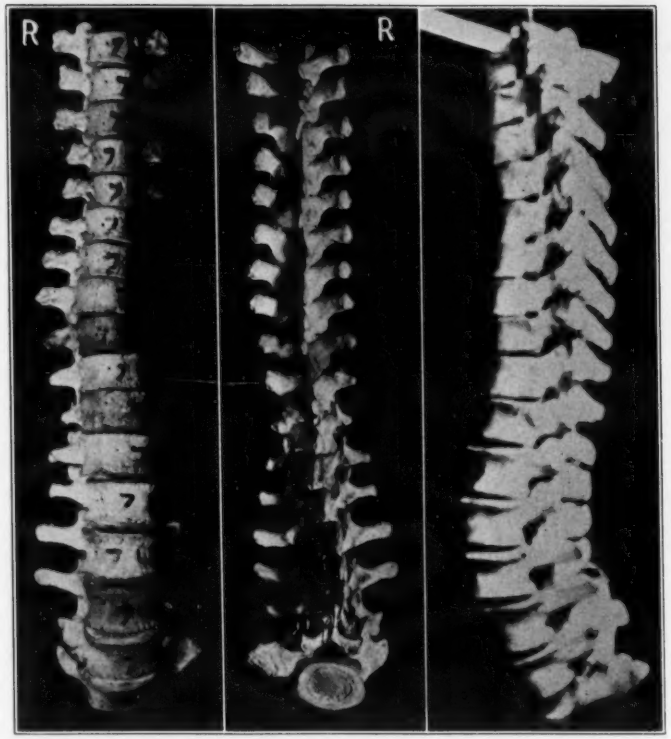

FIG. 6-A

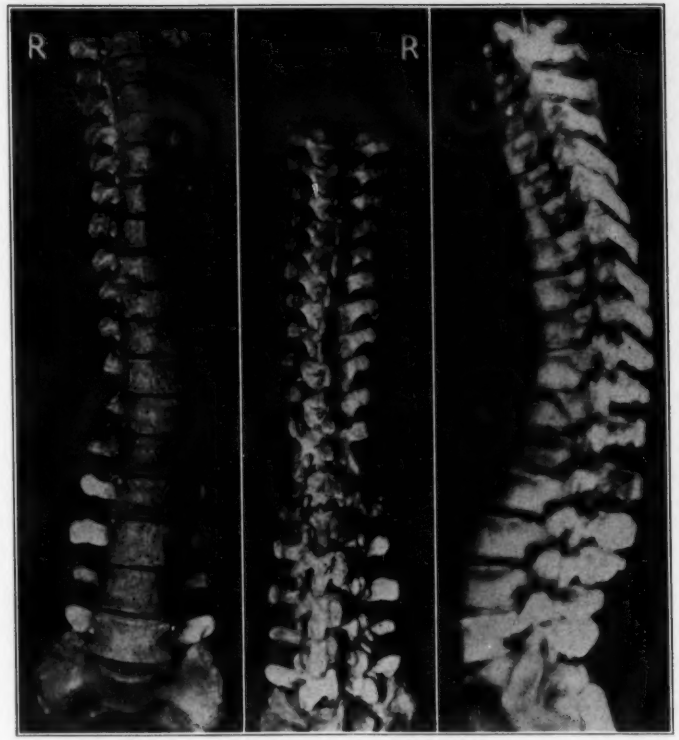

FIG. 6-B

Skeletons of normal adults. Most of the vertebrae are lozenge-shaped, forming a curve.

Fig. 6-A: Specimen 7. Very slight lumbar curve convex to left; marked thoracic curve to right (fifth thoracic to first lumbar); slight upper thoracic curve to left.

Fig. 6-B: Specimen 95. Lumbar curve to left (twelfth thoracic to fifth lumbar); lower thoracic curve to right (fifth to eleventh thoracic); upper thoracic curve to left. The physiological sagittal curves have been preserved.

nor to the proximity of another organ, such as the descending aorta, but is caused by a function continuously at work.

The author reviewed about one hundred spines, and none of them were without a more or less marked lateral curve. Thus there seems to be no doubt about the significance of the asymmetric development of the vertebrae. Most of the asymmetric changes discussed follow a rule, are intimately connected with one another, and represent nothing but the physiological lateral curve of the spine,—that is, they are features of the same phenomenon of physiological scoliosis.

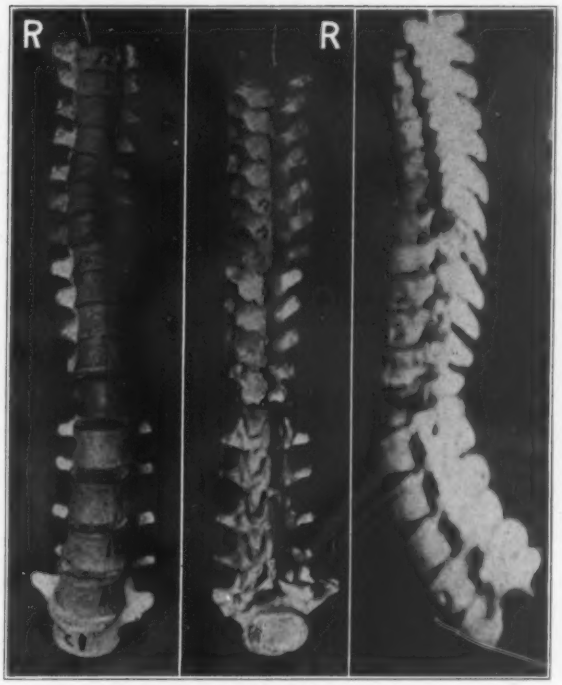

FIG. 6-C

Specimen 12. Lumbar curve to left; lower thoracic curve to right (fourth to twelfth thoracic); upper thoracic curve to left.

The curves themselves showed marked differences in degree, as well as in course. As will be demonstrated, the human gait as the cause of physiological scoliosis plays a definite part. Thus the asymmetric features of the spine are influenced by special etiological factors. Most of the curves were multiple. *The most important finding was that in each specimen the functional Segment II was involved in the formation of the curves.*

On the basis of the investigation, the characteristic features of physiological scoliosis were found to pertain to the following: (1) the lateral curve; (2) elongation of the vertebrae; (3) the spinous processes; (4) the physiological sagittal curves; and (5) the ribs.

Lateral Curve

From the rear, the lateral curve appears much less marked than from the front (Figs. 6-A, 6-B, and 6-C). That is why some of the well-known investigators, such as Lorenz, denied for a long time the existence of physiological scoliosis.

Elongation

Elongation is the most striking asymmetric feature of normal vertebrae, and there is no doubt whatsoever that physiological scoliosis is chiefly due to elongation (Table I).

In Segment II, the elongation was on the right side in 80 per cent. of the specimens. In only 20 per cent., was the elongation on the left. In the latter the lumbar curve and a slight high-thoracic curve pointed to the right. In 10 per cent., the low-thoracic segment formed the lower end of the high-thoracic curve, which pointed to the left. It should be stressed that, *except for the specimens with inverted curves, in all specimens the low thoracic vertebrae showed an elongation to the right.*

Mechanically, the dorsoventral elongation is the gliding of the spine toward the side of the elongation anterolaterally, establishing the physio-

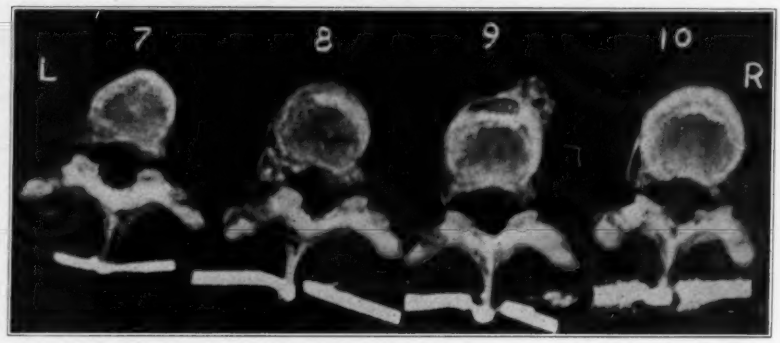

FIG. 7

Seventh, eighth, ninth, and tenth thoracic vertebrae of normal adult, showing elongation to right with deviation of the spinous processes to left as continuation of elongation toward the back. Note diagonal character of physiological scoliosis as well as osteophytes on the side of elongation.

logical scoliotic curve; morphologically, the dorsoventral elongation is the gliding of the spine in the diagonal plane. The vertebrae with marked elongation are, without exception, rhombic in shape; thus physiological scoliosis is built up exclusively of lozenge-shaped vertebrae. The elongation in the diagonal plane is a true scoliotic phenomenon and cannot be compensated for except by means of another curve with opposite convexity.

The physiological scoliosis formed by lozenge-shaped vertebrae represents the prescoliotic stage. The lozenge-shaped vertebrae of a true scoliotic spine show the same elongation which was found to be the important feature in physiological scoliosis (Figs. 4-C, 6-A, 6-B and 6-C). In the latter, however, no wedging occurs, as the normal spine is devoid of those pathological conditions which eventually bring about the collapse of the vertebrae. The latter will be described in detail in a forthcoming study.

In pathological scoliosis the lozenge-shaped vertebrae collapse on the side opposite the original elongation. In physiological scoliosis, in spite of curve and of gravitation, no collapse occurs. The spine remains "prescoliotic" throughout life.

The elongation not only occurs in the convexity of the curve, but

forms it. The anterolateral elongation demonstrates the way in which the spine has moved into the diagonal plane, forming the convexity of the curve. It is of great significance that this motion did not take place in the articulations of the articular processes, but was brought about by the formation of lozenge-shaped vertebrae. The articular processes did not show signs of articular motion. This is an important feature of the prescoliotic stage.

Spinous Processes

The spinous processes in the majority of the specimens were found pointing to the right in Segment I, to the left in Segment II, and to the right in Segment III. Since the vertebral bodies were longer on the left in Segment I, on the right in Segment II, and on the left in Segment III, the direction of elongation was generally opposite the direction of the spinous processes. Thus the spinous processes form the continuation of the elongation posterolaterally, establishing the diagonal character of the scoliotic deformation (Fig. 7). The deviation of the spinous processes is not due to wedging, even in true scoliosis; actually it is part of the original diagonal elongation forming the backward continuation of the lengthened vertebral body.

Physiological Sagittal Curves

The diminishing or disappearance of the kyphotic curve of the thoracic spine and the final increase in the lumbar lordosis comprise one of the chief signs of pathological scoliosis. Physiological scoliosis never shows this sign. The physiological sagittal curves are preserved in physiological scoliosis throughout life.

Ribs

Another important point is the difference in the behavior of the ribs. In spite of marked multiple lateral curves, the ribs showed very little difference between the two sides. This is a surprising fact, as one would have expected a deformation of the ribs consistent with the scoliotic curve.

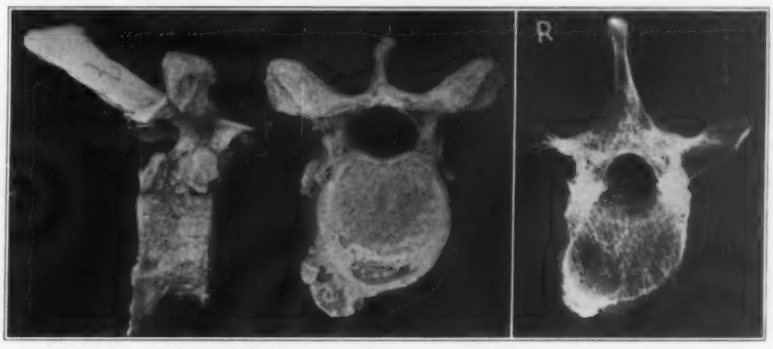

FIG. 8-A FIG. 8-B

Osteophytes start from the ring-like bony rim of the vertebral body as a continuation of the elongation.
Fig. 8-A: Photograph. Fig. 8-B: Roentgenogram.

As the wedging plays but a subordinate rôle in physiological scoliosis, the deformation of the ribs in true scoliosis must be chiefly bound up with the wedging of the vertebrae and with the process that caused it. Wedging and rib deformation, diagonal collapse of the spine, and prominence of the back in any position of the trunk seem to be correlated and subject to the same law. Since the wedging is brought about by that pathological condition which led to the collapse, by finding out the main cause of wedging, the chief pathological and mechanical factors of the pathological scoliotic deformation can be reached, as will be demonstrated in further papers.

OSTEOPHYTES

The first signs of osteophyte production could be detected at about the age of thirty years. Without exception, the osteophyte production started at the ventral edge of the elongation and spread out from there, sometimes extending over the entire circumference of the vertebra in advanced age (Figs. 7, 8-A, and 8-B). The osteophytes changed their site in accordance with the change of site of the elongation. As the elongation was to the left in Segments I and III and to the right in Segment II, the osteophytes were situated on the left side in Segments I and III and on the right ventral border of the vertebrae in Segment II. They always arose from the ring-like bony rim of the circumference of the vertebrae and did not start from the body as Schmorl claimed. Osteophyte production and elongation are due to the same mechanical manoeuvre,—namely, the gliding of the vertebrae on each other in the diagonal plane (Figs. 8-A and 8-B). The friction of the vertebrae against each other should be blamed for the osteophyte production which is a regular by-product of physiological scoliosis.

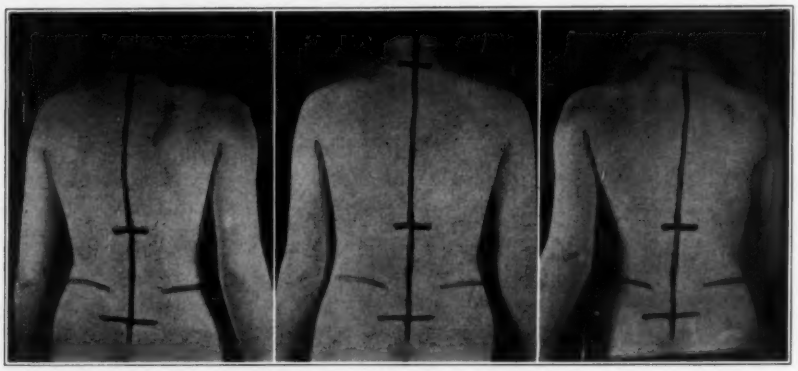

FIG. 9

Marked lateral curves of spine during gait taken by moving pictures. Oscillation of spine to side, depending upon the side of the swinging leg. (See also Figs. 10 and 11.)

Seven-year-old child examined on treadmill.

Left: Right leg swinging; lumbar spine curved to right, thoracic spine to left.

Center: Double support, spine straight.

Right: Left leg swinging; lumbar spine slightly curved to left, thoracic spine to right.

HUMAN GAIT AS CAUSE OF PHYSIOLOGICAL SCOLIOSIS

In order to find the reason for physiological scoliosis the following points should be taken into account:

1. All investigators agree that physiological scoliosis cannot be demonstrated prior to the age of six years. This means that the function which has provoked this phenomenon becomes established just before this age.

2. As no physiological scoliosis could be observed in animals, this condition is bound up with the erect position.

3. In situs inversus viscerum, the course of the scoliotic spine has been found opposite that of normal persons (Gaupp). Thus physiological scoliosis is intimately connected with the unequal distribution of the weight between the right and left sides of the body.

4. Physiological scoliosis becomes more marked with advancing years. Thus it is connected with a function which is continuously at work in the same manner throughout life.

5. Physiological scoliosis is a diagonal deformity of the spine, as is also pathological scoliosis. This means that the function leading to it must exert a deforming power in the diagonal plane of the body.

6. In the present investigation, no normal adult spine was found without a more or less marked scoliotic inclination. This statement implies the existence of an automatic function, but, as the resulting change is of asymmetric nature, the underlying function must be partly of asymmetric nature.

7. As no two spines were found with identical lateral curves, the function leading to the phenomenon is assumed to have marked individual features within a general law.

The only function which meets all of these requirements and is powerful enough to deform such a resistant system as the spinal column is the human gait. The gait becomes established in its perfect automatic manner at about the age of five years when the cerebellum "attains its full size" and exercises full control of the erect position (Gesell). The human gait is bound up with the erect position; it is highly influenced in its symmetry by the unequal distribution of the weight of the organs on the right and left sides; it is automatic; it takes place in most phases in the diagonal plane; it is highly individual; and, finally, it is powerful enough to change the symmetry of spine and vertebrae.

The investigation of the behavior of the spine during gait consisted of the invaluable gait coordinates of Otto Fischer, and of observations of several individuals made by the author by means of moving pictures.

The human gait consists of phases of lost and regained equilibrium. According to Steindler, "locomotion is a rhythmic play of muscle forces between loss and recovery of equilibrium". The three phases of human gait are: (1) standing; (2) swinging; and (3) a small period (double support) between the other two phases when both feet are on the ground. During the entire procedure the center of gravity rises and descends, and

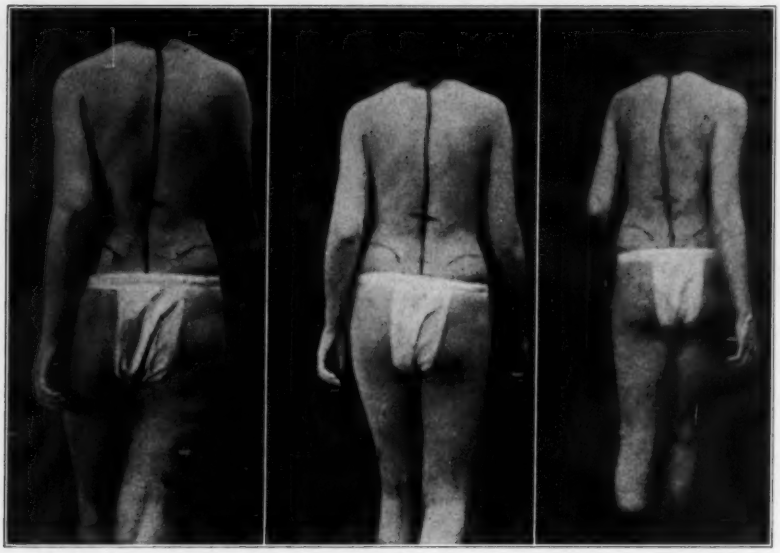

FIG. 10

Normal woman.

Left: Left leg swinging; lumbar spine curved to left, thoracic spine to right.
Center: Double support; straight spine.
Right: Right leg swinging; slight lumbar curve to right, long lumbothoracic curve to left.

tends to come as close as possible to the sagittal plane to prevent falling toward the side of the standing leg.

The evaluation of the coordinates of Fischer shows that the trunk is involved in highly complicated manoeuvres, consisting of rotation of the pelvis in one direction, rotation of the trunk and shoulder-girdle in the opposite direction, and the tendency to keep the head and eyes in the horizontal plane.

While the left leg swings, the pelvis becomes elevated on the left side, the palpating fingers feel the contraction of the sacrospinal muscles on the left side, and simultaneously the lumbar or lumbothoracic segment describes a curve convex to the left. At the same time the left edge of the pelvis rotates forward. The trunk is now in danger of bending and eventually of falling down to the right side. To prevent this, the right shoulder rotates forward, the lowered left shoulder rotates backward, and the trunk tries to bend over to the left side in order to bring the weight above the sagittal plane. This double manoeuvre—the rotation of the shoulders and the bending of the trunk—produces the second curve of the spine, a thoracic curve convex to the right. Then the head bends over to the right, producing a thoracocervical curve convex to the left.

All these manoeuvres are not brought about in the frontal plane; the entire supracoxal part of the body is in the diagonal plane, pointing in the lumbar segment from left front toward right back, in the lower thoracic segment from right front toward left back, and in the upper thoracic seg-

ment from left front toward right back. Thus, roughly, there result a lumbar and cervical curve convex to the left and a thoracic curve convex to the right. Then follows a phase when both feet hit the ground at the same time for a very short period. In this phase of double support, the body is nearly in the frontal plane. Then the right leg starts swinging and the same bending-rotating manoeuvre produces a spinal curve, in every respect opposite to the previous curves.

Here, however, innate asymmetries intervene. The heavier right side with its more powerful muscles performs movements which are equal in form but not in scope to those performed by the left side. Fischer found that the pressure which the right foot exerted on the ground while walking exceeded by nine pounds the pressure exerted by the left foot. An evaluation of the records of Plato Schwartz showed that the pressure of the right foot exceeded that of the left by about 2 per cent. Standing on two scales at the same time showed roughly from 5 to 25 per cent. higher pressure in favor of the right side. Thus the kinetic energy must sharpen the curves of the spine on one side of the body more than on the other side. It should be stressed that the formation of the most regular of the lateral curves—namely, that in Segment II—is essentially facilitated by the constant pull of the heart. The heart, like a hanging weight, moves the spine to the right side; it helps to establish and to maintain the deviation.

During the author's observations, for the purpose of moving pictures,

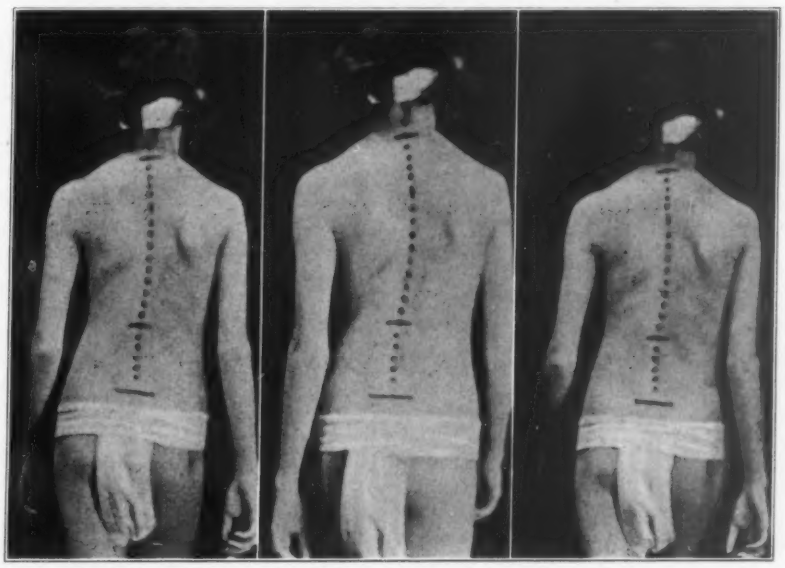

FIG. 11

Habitual scoliosis.
Left: Double support; lumbar curve to left, thoracic curve to right.
Center: Left leg swinging; scoliotic curves markedly increased.
Right: Right leg swinging; scoliotic curves markedly diminished.

the spinous processes were marked with a skin pencil. It is true that the skin cannot travel to such an extent as that of the underlying spinous processes; however, in spite of the minor changes in the skin, the pictures revealed the events as regards both law and individuality (Figs. 9, 10, and 11). In none of the cases investigated could there be observed a perfect equality of the curves when the step changed. In one instance the scoliosis consisted of three curves to one side and only one curve to the other side. Sometimes the lumbar curve travelled as high as the upper thoracic region on one side, while on the other side it remained stationary.

The picture of a scoliotic child was very interesting. While one leg was swinging, the curves became corrected to a high degree; while the other leg was swinging, they became markedly increased, demonstrating the intrinsic connection between gait and deformity.

The individual variations have apparently two sources: (1) the unequal distribution of weight and muscle power, and (2) the already developed physiological scoliosis, which, as the example of the scoliotic individual revealed, cannot be "overcorrected" by the changing of the step. The significance of the gait in the production and prognosis of pathological scoliosis is obvious, as will be explained in further studies.

The findings presented may be utilized also in anthropological studies. As the gait of modern man has such far-reaching consequences on the spine, it is possible that age and manner of life and of locomotion may be deduced from the shape of the vertebrae in ancient man.

CONCLUSIONS

Measurement of the twelve thoracic and five lumbar vertebrae of twenty-one normal spines and of one scoliotic spine, ranging in age from six to eighty-six, elicited the following conclusions:

1. The postnatal development of normal spines becomes asymmetric about the age of six, progressing with advancing age.

2. The asymmetry concerns the vertebral body and pedicles as well as the arches. The most striking feature of the asymmetries found was the dorsoventral elongation of the vertebral bodies: in the upper thoracic region, on the left; in the lower thoracic segment, on the right; and in the lumbar region, on the left. Besides this, the lengthening of the pedicles on the side of the elongation and broadening of the pedicles on the other side, and the deviation of the arches opposite the side of the dorsoventral elongation could be regularly observed.

3. Since the spine in all of the specimens except that of the normal six-year-old child showed marked lateral deviation, the asymmetric postnatal development of the spine represents physiological scoliosis.

4. In physiological scoliosis, contrary to the findings in pathological scoliosis, the wedging of the vertebrae plays but a subordinate rôle. The curves throughout are composed of lozenge-shaped (rhombic) vertebrae, representing the prescoliotic stage of the deformation without marked signs of motion in the articular processes. Further differences between

physiological and true scoliosis are as follows: In physiological scoliosis the physiological *sagittal* curves never disappear, and, furthermore, in none of the specimens examined were all of the bone elements of the same vertebra concerned at the same time; in true scoliosis all of the parts of the vertebra are more or less deformed.

5. The osteophyte production always starts at the ventral edge of the dorsoventral elongation.

6. In physiological scoliosis, as well as in pathological scoliosis, the deformation of the spine takes place in the diagonal plane, never in the exact frontal plane.

7. The cause of physiological scoliosis is the human gait, which forces the spine into a threefold curve, alternately changing at every step. However, the innate normal asymmetries of the human body eventually establish permanent lateral curves of the spine, showing marked individual variations within the general law.

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REFERENCES

Dieulafé, Léon, et Dieulafé, Raymond: La colonne vertébrale. Anatomie chirurgicale, variations. Pathologie. Paris, J. B. Baillière et Fils, 1930.

Farkas, Aladár: Die physiologische Skoliose. Verhandlungen der Deutschen Orthopädischen Gesellschaft, 19ter Kongress, 1924. (Beilageheft der *Zeitschrift für orthopädische Chirurgie*, XLVI, 284.) Stuttgart, Ferdinand Enke, 1925.

Über Bedingungen und auslösende Momente bei der Skoliosenentstehung (Versuch einer funktionellen Skolissenlehre). Stuttgart, Ferdinand Enke, 1925.

The Pathogenesis of Scoliosis. (Read before the Convention of the Iowa State Pediatric Society, April 30, 1940.)

Fischer, Otto: Der Gang des Menschen. Leipzig, Hirsch, 1906.

Gaupp, E. W. T.: Die normalen Asymetrien des menschlichen Körpers. Jena, Gustav Fischer, 1909.

Gesell, Arnold; and others: The First Five Years of Life: A Guide to the Study of the Preschool Child from the Yale Clinic of Child Development. New York, Harper & Brothers, 1940.

Lorenz, Adolf: Pathologie und Therapie der seitlichen Rückgrat-Verkrümmungen (Scoliosis). Wien, Alfred Hölder, 1886.

Sabatier: Traité complete d'anatomie. Paris, 1777.

Schmorl, Georg, und Junghanns, H.: Archiv und Atlas der normalen und pathologischen Anatomie in typischen Röntgenbildern. Die gesunde und kranke Wirbelsäule im Röntgenbild: Pathologisch-anatomische Untersuchungen. (Fortschritte auf dem Gebiete der Röntgenstrahlen Ergänzungsband XLIII.) Leipzig, Georg Thieme, 1932.

Schwartz, R. P.; Heath, A. L.; Misiek, William; and Wright, J. N.: The Making and Interpretation of Electrobasographic Records of Gait. The Influence of Rate of Walking and the Height of Shoe Heel on Duration of Weight-Bearing on the Osseous Tripod of the Respective Feet. J. Bone and Joint Surg., XVI, 343, Apr. 1934.

AN ANALYTICAL STUDY OF BONE AND JOINT LESIONS IN RELATION TO CHRONIC PULMONARY TUBERCULOSIS

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In this paper a study has been made of the tuberculous orthopaedic patients who entered the San Francisco Hospital in the Tuberculosis Service of the University of California from January 1920 to July 1935.

It is difficult to obtain a clear concept of the outcome of tuberculous bone and joint disease unless a complete analysis is made of a series of cases extending over a number of years. The high mortality which the authors encountered in a general tuberculosis hospital was so at variance with reports of the usual outcome of this form of tuberculosis, that it was thought of sufficient importance to analyze the cases.

Many studies of the end results have been reported in the literature, but these in greater part were based upon series of cases which were selected for conservative or surgical treatment, or a combination treatment. The low mortality and the apparently numerous successful results reported in these papers lead to the conclusion that bone and joint tuberculosis is particularly amenable to treatment.

Other studies, however, especially those of Cleveland[1], deal with the problem viewed in a broader manner. His findings show that the disease is serious, successful results are fewer, and the mortality is high. As is so well emphasized by Cleveland, the authors also feel that this latter type of survey, by not excluding any cases whatsoever, presents a much more typical cross section of the results of tuberculous joint infection. Admittedly, series such as these may overemphasize the poor results, since they include many patients who were in the terminal stage of far-advanced pulmonary tuberculosis, but, even so, the authors think the all-inclusive survey gives the more accurate picture of tuberculous joint disease.

Though constantly requiring re-emphasis, it is well known that tuberculous bone and joint infection is usually secondary to some primary tuberculous focus. The treatment of joint disease cannot be considered independently of the treatment of the general infection. Therefore, in the study of a large group of tuberculous patients with all manifestations of the disease, many pertinent facts which might be overlooked in the study of a selected series should come to light. Details thus revealed may be advantageously applied to the treatment of joint disease with the purpose of lowering mortality rates and increasing the number of good end results.

METHODS OF ANALYSIS

Cleveland's article appeared in the literature at the time these data were being collected. The authors are in accord with his proposal that a uniform classification of types or degrees of tuberculous disease is necessary for a basis of comparison in an end-result study. While an attempt has been made to follow his general plan rather than to use his classification, this series has been analyzed with especial reference to pulmonary disease, and the standard classification of the National Tuberculosis Association has been used.

DIAGNOSIS

The San Francisco Hospital is a municipal institution which admits all patients upon whom either a positive or tentative diagnosis of tuberculosis has been made. In most of the cases studied, the diagnosis was proved through confirmation in the laboratory and often by postmortem examination. For those whom it was not possible to reexamine there were sufficient data to classify the end results for this study.

Diagnosis, especially if the lungs were involved, was fairly obvious in advanced cases, but in the early cases it was often difficult or uncertain. Usually the diagnosis was made upon clinical, roentgenographic, and laboratory findings. Wherever possible, however, the diagnosis was substantiated by bacteriological examination, guinea-pig inoculation, and at autopsy.

TREATMENT

The program of treatment placed primary emphasis upon the systemic tuberculous infection, and secondarily concerned itself with the specific focal disease. The general regimen consisted of bed rest in the

TABLE I

NUMBER AND PERCENTAGES OF LESIONS IN PATIENTS WITH TUBERCULOUS BONE AND JOINT DISEASE

Classification	Total Patients		Total Lesions		Survivors				Non-Survivors			
					Patients		Lesions		Patients		Lesions	
	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.
Non-pulmonary..	42	26.3	53	26.1	26	31.3	29	28.1	16	20.8	24	24
Minimal.....	33	20.6	45	22.2	23	27.7	35	34.0	10	13.0	10	10
Moderately advanced.....	25	15.6	28	13.8	14	16.9	15	14.6	11	14.3	13	13
Far advanced....	60	37.5	77	37.9	20	24.1	24	23.3	40	51.9	53	53
Totals.....	160	100.0	203	100.0	83	100.0	103	100.0	77	100.0	100.0	100.0

TABLE II

REGIONAL DISTRIBUTION OF BONE AND JOINT TUBERCULOSIS IN 160 PATIENTS

Location	No.	Per Cent.
Spine	67	33.0
Hip	30	14.8
Fingers, toes, and long bones	22	10.8
Knee	17	8.4
Sacro-iliac	15	7.5
Sternum	8	3.9
Elbow	8	3.9
Ribs	7	3.4
Shoulder	7	3.4
Ankle	6	2.9
Wrist	4	2.0
Tarsus	4	2.0
Irregular bones, ilium, sacrum, mandible	5	2.5
Tendon, bursae	3	1.5
Total	203	100.0

open air, Rollier or light therapy, high-caloric diet, and some form of cod-liver oil.

Surgical procedures were only employed after a long period of conservative treatment. During this time, the usual orthopaedic measures of deformity prevention or correction, and joint immobilization were constantly in use.

Surgical methods included arthrodesis, eradication of focus by amputation, aspiration, or incision of abscesses. The latter treatment was practised only when skin perforation was imminent, or when a sinus was already present.

In this series the proportion of lesions treated surgically is admittedly small, eighty-five out of the 203 lesions, or 41.9 per cent. The reason for this was that some of the patients had been treated elsewhere, and a large number of the patients had moderately or far-advanced pulmonary lesions (See Table I).

ANALYSIS

Occurrence

Region Affected: The number of patients who entered the Service during these years was 4252; of these, 160 or 3.76 per cent. had bone and joint disease, but many had multiple lesions, thus bringing the number for statistical data up to 203. This study is based on the number of lesions, and not on the number of patients. It is of great interest that the 4 per cent. of bone and joint lesions in Cleveland's much larger series so closely approximated the percentage of the authors'. In other statistical studies as well, it may be seen that the greatest number of these lesions appeared in the spine and other weight-bearing joints (See Table II).

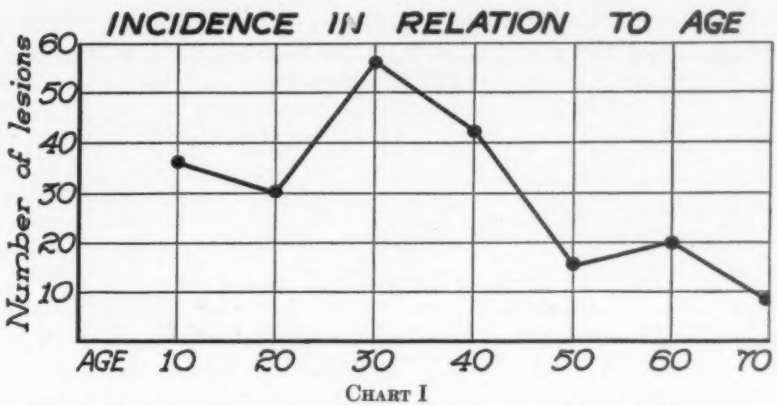

CHART I

The incidence in relation to age is based on 203 lesions, rather than 160 patients, because of the multiple lesions counted.

Age Incidence: The years from fifteen to thirty-five are designated as the period of greatest incidence of pulmonary tuberculosis. It is very striking, as shown in Chart I, that these are also the years in which tuberculous bone and joint lesions appear most frequently. The curve indicates that 164 or 81 per cent. of these lesions occurred in patients under the age of forty years. In many of the older patients the onset had been during the earlier years of life. This is an important fact and may be added evidence in support of the contention that this form of the disease is secondary to other tuberculous foci.

Race: Race has been recorded rather than nationality. On the Pacific coast there are a relatively great number of inhabitants belonging to the yellow and mixed races, and relatively few to the black. Racial classification is of importance since, as is well known, these peoples (yellow, mixed, and negro) have very little resistance to tuberculous infection.

Relation of Bone and Joint Tuberculous Lesions to the Various Stages of Pulmonary Disease

The incidence of bone and joint tuberculosis in the various groups, following the classification of the National Tuberculosis Association is shown in Table I.

In the first group of forty-two patients—those with no clinical evidence of pulmonary disease—there were thirty-four patients who had other manifestations of tuberculosis (forty-five lesions). These associated lesions were either multiple bone and joint involvement, abscesses, extensive tuberculosis of the genito-urinary tract, widespread tuberculosis of the skin, generalized tuberculous adenitis, polyorrhomenitis, and some, eventually miliary tuberculosis. Only eight patients had no other focus of disease.

Another important factor in this group pertains to the children. In the examinations of the roentgenograms of the twenty-four younger patients it was found that although no parenchymal lesion was discernible, twenty-one, or 87 per cent., showed evidence of either calcification or en-

TABLE III

END RESULT OF 203 TUBERCULOUS BONE AND JOINT LESIONS IN 83 SURVIVORS AND 77 NON-SURVIVORS

Location	Total Lesions	Lesions in 83 Survivors						Lesions in 77 Non-Survivors	
		Well		Improved		Unimproved			
		No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.
Spine	67	7	10	15	22	7	10	38	58
Hip	30	9	30	4	13	4	13	13	44
Fingers, toes, and long bones	22	4	18	3	14	5	23	10	45
Knee	17	3	18	5	29	2	12	7	41
Sacro-iliac	15	1	7	4	26	1	7	9	60
Sternum	8	0	0	1	12	2	25	5	63
Elbow	8	2	25	2	25	0	0	4	50
Ribs	7	2	29	1	14	1	14	3	43
Shoulder	7	0	0	1	14	0	0	6	85
Ankle	6	4	66	1	17	1	17	0	0
Wrist	4	1	25	0	0	2	50	1	25
Tarsus	4	1	25	1	25	0	0	2	50
Irregular bones	5	0	0	2	40	1	20	2	40
Tendon, bursae	3	1	33	2	67	0	0	0	0
Totals	203	35	17	42	21	26	13	100	49

largement of the hilum glands. It is possible only by frequent and careful examinations of the chest, including the roentgenograms, to ascertain pulmonary lesions associated with the joint disease; the search for these should be unremitting since these lesions bear such a great influence upon the outcome of the local lesions. This applies to both the adult and the child.

In the examination of the pulmonary group, comprising almost 74 per cent. of the cases and an equal per cent. of the lesions, the bone and joint complications were found to be greatest in the patients with far-advanced disease. This is to be expected, since it is in this stage that the greatest number of other complications occur, and is well proved by past experiences. In the minimal and moderately advanced groups, the bone and joint lesions occur less frequently than in the far-advanced group, as indicated in Table I.

End Results

A study of Table III reveals the rather startling and certainly discouraging fact from the orthopaedic standpoint, that only thirty-five, or 17 per cent., of the total number of lesions are recorded as well. Forty-two, or 21 per cent., were improved; twenty-six, or 13 per cent., unimproved; and 100, or 49 per cent., were in patients who have

died. At first glance it would appear that this is a most unusual series of tuberculous joints; on the contrary, the authors feel that it is not unusual since all the patients entering a large general tuberculosis hospital have been included.

Those who lived will first be considered, and then those who have died. From Table IV it may be seen that in the survivors, twenty-nine of the lesions were in the non-pulmonary group, thirty-five in the minimal, fifteen in the moderately advanced, and twenty-four in the far-advanced pulmonary group. The preponderance of lesions in the first two divisions with no or minimal lung involvement indicates that with increased pulmonary disease the local disease becomes more serious. This is also true when the outcome is considered from the standpoint of the patient rather than the lesion.

In the far-advanced group it is of importance to note that each of the nine lesions reported as well was in a patient who had an arrested bone or joint lesion of many years' duration, and it is, of course, the bone and joint lesions which are here recorded as being well. By "well" is meant that in bone the lesion has been arrested; in joint there is ankylosis, either with impairment or loss of motion and function. Of the other patients in this group, several are under treatment and others were still under observation for their pulmonary disease when last seen.

Analysis of Deaths

Death in Relation to Age: Chart II shows the mortality in relation to age, and clearly demonstrates the gravity of tuberculous joint disease in the second and third decades and in the aged. These are also the age periods in which pulmonary and other tuberculous diseases are most frequently fatal. Thus either of these manifestations of the disease is

TABLE IV

END RESULT OF BONE AND JOINT LESIONS IN RELATION TO LUNG DISEASE IN 160 PATIENTS

Condition of Local Lesion	Total		Non-Pulmonary (*42 Patients*)		Pulmonary (*118 Patients*)					
					Minimal (*33 Patients*)		Moderately Advanced (*25 Patients*)		Far Advanced (*60 Patients*)	
	Lesions	Per Cent.	Lesions	Per Cent.	Lesions	Per Cent.	Lesions	Per Cent.	Lesions	Per Cent.
Well	35	17.2	9	17.0	15	33.3	2	7.2	9	11.7
Improved	42	20.7	16	30.2	12	26.7	7	25.0	7	9.1
Unimproved	26	12.8	4	7.5	8	17.8	6	21.4	8	10.4
Lesions in Survivors	*103*	*50.7*	*29*	*54.7*	*35*	*77.8*	*15*	*53.6*	*24*	*31.2*
Lesions in non-survivors	100	49.3	24	45.3	10	22.2	13	46.4	53	68.8
Totals	203	100.0	53	100.0	45	100.0	28	100.0	77	100.0

TABLE V

NUMBER AND LOCATION OF LESIONS IN NON-SURVIVING PATIENTS

Location	Total (*160 Patients*)			Non-Pulmonary (*42 Patients*)			Minimal (*33 Patients*)			Moderately Advanced (*25 Patients*)			Far Advanced (*60 Patients*)		
	Total Lesions	Lesions in 77 Non-Surviving Patients		Total Lesions	Lesions in 16 Non-Surviving Patients		Total Lesions	Lesions in 10 Non-Surviving Patients		Total Lesions	Lesions in 11 Non-Surviving Patients		Total Lesions	Lesions in 40 Non-Surviving Patients	
		No.	Per Cent.		No.	Per Cent.		No.	Per Cent.		No.	Per Cent.		No.	Per Cent.
Spine	67	38	57	22	12	55	15	6	40	7	3	43	23	17	74
Hip	30	13	43	9	5	56	6	1	17	4	1	25	11	6	55
Fingers, toes, and long bones	22	10	45	3	0	0	6	1	17	4	4	100	9	5	55
Knee	17	7	41	1	0	0	6	0	0	3	2	67	7	5	71
Sacro-iliac	15	9	60	5	3	60	4	1	25	1	0	0	5	5	100
Sternum	8	5	63	3	2	67	0	0	0	1	0	0	4	3	75
Elbow	8	4	50	4	1	25	1	0	0	0	0	0	3	3	100
Ribs	7	3	43	1	0	0	1	0	0	2	0	0	3	3	100
Shoulder	7	6	85	0	0	0	1	1	100	2	2	100	4	3	75
Ankle	6	0	0	1	0	0	2	0	0	1	0	0	2	0	0
Wrist	4	1	25	0	0	0	1	0	0	1	0	0	2	1	50
Tarsus	4	2	50	1	0	0	1	0	0	1	1	100	1	1	100
Irregular bones	5	2	40	3	1	33	1	0	0	0	0	0	1	1	100
Tendon, bursae	3	0	0	0	0	0	0	0	0	1	0	0	2	0	0
Totals	203	100	49	53	24	45	45	10	22	28	13	46	77	53	69

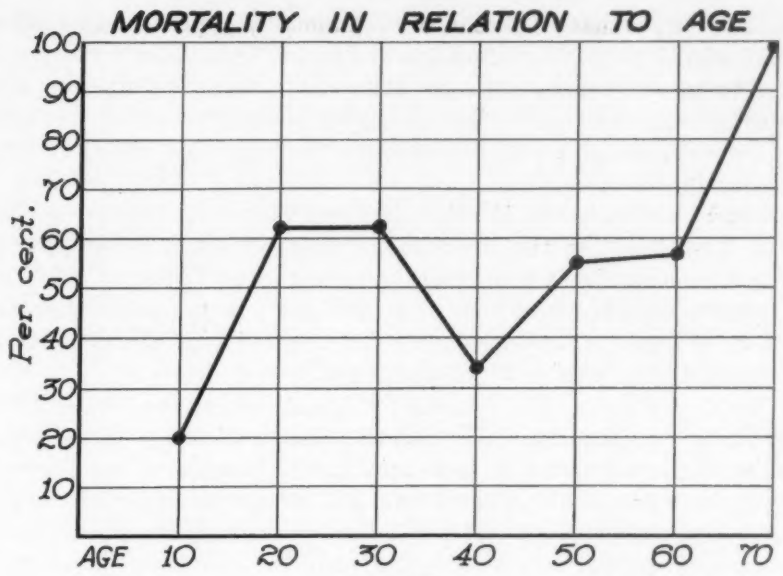

CHART II

The mortality in relation to age is based upon 203 lesions, rather than 160 patients, because of the multiple lesions counted.

often the cause of death, rather than the bone or joint lesion. This, however, does not detract in any way from the serious importance of bone and joint disease which may be present at these ages.

Death in Relation to Race: The susceptibility of the yellow, mixed, and black races to tuberculosis is well known. There were in our series forty-nine lesions occurring in one of the above races, with a mortality of 70 per cent. (based on the number of lesions). In the 154 lesions of the white race, the mortality was by contrast only 43 per cent.

Death in Relation to Pulmonary Involvement: (See Table V.)

(a) Non-pulmonary group: Sixteen patients, with twenty-four, or 45 per cent. of the fifty-three bone and joint lesions, died. This is not unexpected, particularly as they all had multiple lesions. There were twelve instances of tuberculosis of the spine, all of the patients having large abscesses, three of which ruptured internally and six others externally. There was also a high incidence of draining sinuses among the additional four instances of tuberculosis of the hip; three of the sacro-iliac; two of the sternum; and one each, of the sacrum and elbow. Additional complications, one or more of which were present in each case, consisted of paraplegia, meningitis, miliary tuberculosis, multiple bone and joint infection, genito-urinary and glandular foci, skin ulcers, and decubiti. In three instances death could be directly attributed to postoperative shock.

(b) Pulmonary group: Half of the patients with joint involvement plus pulmonary disease died. The stage of the lung disease had a very definite bearing on the outcome as shown in Table V, which dis-

closes that 22 per cent. of the minimal, 46 per cent. of the moderately advanced, and 69 per cent. of the advanced group died. This rapidly rising mortality rate corresponds to the experiences with lung diseases alone or with complications other than orthopaedic ones, and serves to emphasize the need for giving primary consideration to the patient rather than to his local disease.

Death in Relation to Multiple Lesions: The seriousness of multiple lesions is evident. In the 160 patients, there were thirty-four who had multiple bone and joint involvement, making in all 77 lesions. Of these thirty-four patients, seventeen, or 50 per cent., died, and the lesions in eight, or 23.5 per cent., were unimproved; in four, or 11.8 per cent., improved; and in five, or 14.7 per cent., well.

Death in Relation to a Positive Sputum Examination: There has not been enough emphasis placed upon the existence of a positive sputum examination in patients who have orthopaedic lesions. The authors believe that the presence of tubercle bacilli in the sputum is a contra-indication to surgical treatment. Of fifty-seven patients, with sixty-eight lesions and positive sputum, thirty-seven died; and the lesions in eight were unimproved; in eight, improved; and in only four, well. In other words, 79 per cent. of the patients with positive sputum either died or failed to improve.

Death in Relation to Existence of a Sinus: It has long been recognized that a draining sinus greatly increases the hazards of tuberculous disease. In this series, ninety-two patients had this complication, of whom fifty, or fifty-four per cent. died. Of the forty-two survivors, thirteen patients had lesions which were unimproved, seventeen improved, and twelve were well; sepsis and amyloid disease were the cause of death in many instances.

Death in Relation to Treatment: A discussion of methods of treatment is not being presented in this paper, but the cases have been segregated into two divisions. The first consists of 118 lesions treated by rest and immobilization; sixty-three, or 53 per cent., were in patients who died; seventeen, or 14 per cent., were unimproved; nineteen, or 16 per cent., improved; and nineteen, or 16 per cent., well. Admittedly many of these lesions were in the advanced pulmonary group, and many had complications.

In the second division there were eighty-five lesions treated surgically. Many of the operations were merely sinus excision or abscess incision, although amputations and arthrodeses are also included. Of these thirty-three were in the non-pulmonary group, and fifty-two in the groups with pulmonary involvement. The end results were: thirty-eight, or 44 per cent., in patients who died; eight, or 9 per cent., unimproved; twenty-three, or 27 per cent., improved; and sixteen, or 19 per cent., well.

The results of treatment are difficult to evaluate when they are based on patients. In a few of the patients with multiple lesions, one joint may have been treated by rest or immobilization only, and the associated lesion by some form of surgery. Then there was a variance

in the final result in six of the patients in whom one joint was unimproved, and the other well or improved. In the count, three were considered favorable and three unfavorable in result. The mortality then, in relation to treatment, was as follows: Of eighty-eight patients treated by rest or immobilization only, forty-nine died; and the lesions in ten were unimproved; in fifteen, improved; and in fourteen, well. Of seventy-two patients treated surgically, twenty-nine died; and the lesions in six were unimproved; in twenty-one, improved; and in sixteen, well.

SUMMARY AND CONCLUSIONS

The analysis of the bone and joint tuberculosis encountered in a general tuberculosis hospital during the fifteen years from 1920 to 1935 shows that:

1. Of 4252 tuberculous patients, 160 or 3.76 per cent. had 203 single or multiple tuberculous joint and bone lesions, which were usually secondary to some other tuberculous focus, most frequently in the lungs.

2. Of these 160 patients, 118, or 73.7 per cent., had chronic pulmonary tuberculosis; forty-two, or 26.3 per cent., had no pulmonary involvement but had fifty-three bone and joint lesions, or 26 per cent., of the total orthopaedic lesions. Of these patients with fifty-three lesions, forty-five had manifestations of tuberculosis elsewhere,—in bones and joints, or skin, or as adenitis, polyorrhomenitis, etc. In only eight was one joint the sole focus of tuberculosis.

3. Bone and joint tuberculous disease affects more often the weight-bearing joints in the order indicated in Table II.

4. It is most prevalent in the second and third decades of life.

5. When tuberculous bone and joint lesions are associated with pulmonary disease, the outcome is greatly influenced by the degree of lung involvement and is particularly serious in the moderately advanced and far-advanced stages. Complications were present in the greatest number in the patients with far-advanced pulmonary tuberculosis. The orthopaedic lesions, therefore, should be secondary in importance to the care of the pulmonary disease. Surgery for patients in these advanced stages of the disease must be carefully considered; conservative measures alone are the methods of choice.

6. The prognosis is more serious in patients who have tubercle bacilli in the sputum; in patients in whom there is a draining sinus or multiple abscesses (very often a general toxaemia ensues in the former, and the development of amyloid disease in the latter); and in those with forms of tuberculosis other than pulmonary.

7. The end results show that in 160 patients with 203 bone and joint lesions, thirty-five or 17 per cent. of the lesions were well; forty-two, or 21 per cent., were improved; twenty-six, or 13 per cent., were unimproved; and 100, or 49.3 per cent., were in patients who have died.

8. In a study of bone and joint tuberculosis in a general tuberculosis hospital where far-advanced pulmonary cases constitute a large

proportion of the patients, the mortality statistics are necessarily higher than in a service with orthopaedic patients alone. In this series the mortality was highest in the second, third, and seventh decades. It was greater in the pulmonary cases (51 per cent. of the patients with 50 per cent. of the lesions) than in the non-pulmonary cases (38 per cent. of the patients with 45 per cent. of the lesions); and greatest in those with multiple joint lesions. It was also higher in the yellow, mixed, and negro races. This indicates an unusual susceptibility and lowered resistance, and for this reason very careful consideration must be given each patient before surgical procedure is undertaken. Of the patients with positive sputum 79 per cent. died or had lesions which failed to improve; and of ninety-two patients with one or more sinuses, sixty-three died or had lesions which failed to improve.

9. An analysis of the 118 bone and joint lesions treated by rest and immobilization shows that sixty-three, or 53 per cent., were in patients who died; seventeen, or 14 per cent., were unimproved; nineteen, or 16 per cent., were improved; and nineteen, or 16 per cent., were well. Of the eighty-five joints treated by surgery of any kind, thirty-eight, or 44 per cent., were in patients who died; eight, or 9 per cent., were unimproved; twenty-three, or 27 per cent., were improved; and sixteen, or 19 per cent., were well.

10. Because this study has brought out so conclusively the high mortality in bone and joint tuberculosis when associated with pulmonary involvement, the authors wish to emphasize the necessity of a complete physical examination including routine laboratory work and roentgenograms of the chest for every patient.

[1] Cleveland, Mather: Surgical Treatment of Joint Tuberculosis. Surg. Gynec. Obstet., LXI, 503, 1935.

A SIMPLE METHOD OF TWO-STAGE TRANSPLANTATION OF THE FIBULA FOR USE IN CASES OF COMPLICATED AND CONGENITAL PSEUDARTHROSIS OF THE TIBIA *

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The purpose of this communication is to describe a simple method of two-stage transplantation of the fibula into the tibia, and to report the results obtained by its use in a group of nine cases of complicated pseudarthrosis of the tibia.

HISTORICAL

Transplantation of the fibula to replace defects in the tibia was first conceived by Hahn in 1884, but he transferred only the upper end into the proximal fragment. Subsequently Codivilla pointed out the advisability of also transferring the lower end into the distal fragment of the tibia in order to overcome the valgus deformity of the foot. Huntington perfected the technique of this operation in 1905, and reported a case in which he had successfully bridged a gap of five inches in the tibia. He described a two-stage procedure in which he first exposed the shaft of the fibula on a level with the lower end of the upper fragment of the tibia. He divided the fibula and transplanted the upper end of the distal fragment into a cup-shaped depression in the tibia. After fixation in a plaster casing for eight to ten weeks, he performed the second stage of the operation. The lower portion of the fibula was exposed on a level with the upper end of the distal tibial fragment and transplanted into a cup-shaped depression.

Stone, in 1907, reported a modification of the Huntington technique, in which he split the distal portion of the fibula shaft into two halves and then divided one half at the external malleolus. He transferred this fragment into the distal end of the tibia, and was thus able to elongate a short leg. Campbell, in 1919, reported three cases of tibial pseudarthrosis in which he excised the cartilage and ligaments from the upper tibiofibular articulation, and buried the head in the tibial tuberosity. He performed this operation as a preliminary to later bone-grafting operations on the tibia, and did not consider it necessary to transfer the lower end. He pointed out the stabilizing effect of this operation upon the pseudarthrosis, and considered that it increased the chances of a successful result from the bone graft.

The literature abounds with reports of cases, either single or in small groups, where transference of the fibula was done with successful results. In general, the method was employed only when there existed large defects in the tibia, and varying operative techniques were used, often involving

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complete separation of the transplanted portion of the fibula from its blood supply. In particular, the method proved useful in defects resulting from diaphyseal resections of the tibia for acute osteomyelitis.

INDICATIONS

It is the author's belief that transference of the fibula into the tibia has a much wider application than this; and that it ought to be considered in all cases of complicated or infected pseudarthrosis, even where there is no gross loss of tibial substance, particularly when bone-grafting operations have previously failed, or seem for the moment to hold very little promise of success. In the author's hands the method also proved particularly valuable in cases of congenital pseudarthrosis or of congenital bowing in which pseudarthrosis subsequently developed.

The operation here described was first employed by the author in 1926. The technique was later improved and simplified, and the method has now been employed in a total of nine cases which are herewith reported. In one early case (Case 2), it was necessary to operate three times before union of the upper end of the fibula to the tibia was obtained. In one other case (Case 9), union of the upper end was doubtful, but, since healing of the pseudarthrosis took place promptly afterward, it would seem to be fair to consider the result successful. In the other cases osteosynthesis of the fibula to the tibia resulted uneventfully.

OPERATIVE PROCEDURE

The operation is best done in two stages although in one case both ends were transplanted at the same time. The two-stage method has the advantages of lessening the risk of dislodging the end of the fibula from its connection with the tibia, of shortening the time of the operation, and of reducing the severity of the postoperative reaction.

First Stage of Operation (Upper End)

The operation should be performed with a tourniquet about the thigh. An oblique incision is made over the lateral aspect of the knee and upper leg, beginning at a point three inches above the head of the fibula at the posterior border of the biceps femoris tendon, and extending downward and forward to the tibial crest at a point two to three inches below the tibial tubercle. The skin and superficial fascia are dissected back on either side of the incision to expose the deep fascia, the head of the fibula, the lateral surface of the external tuberosity of the tibia, and the tibial crest (Figs. 1, 2-A, 2-B, and 2-C). The common peroneal nerve is identified behind the biceps tendon, picked up in a tape, and carefully dissected free as it passes around the neck of the fibula and divides into its deep and superficial branches. A transverse incision is now made along the inferior border of the lateral tuberosity of the tibia at the point of attachment of the tibialis anterior muscle, and extended anteriorly and downward, following this border as it curves distally, to meet the tibial crest. This incision

extends posteriorly until it meets the incision over the neck of the fibula which has exposed the common peroneal nerve (Fig. 2-A). With a periosteal elevator the muscle flap, which has thus been outlined, is stripped away from its attachment to the upper end of the fibula and the lateral tuberosity of the tibia, and retracted downward. By retracting the nerve with the tape and stripping the muscles away from the fibula, an excellent exposure is obtained of the upper part of the fibula, of the shelving under surface of the lateral tuberosity of the tibia, and of the interosseous membrane. The anterior tibial artery and vein may be seen emerging from the popliteal space through the opening at the upper edge of the interosseous membrane, and coursing downward on the anterior surface of the latter. These vessels interfere with the transference of the fibula, and must usually be ligated and cut.

The fibula is now divided at the neck with a sharp osteotome (Fig. 2-B), and the upper end of the distal fragment is seized with a bone clamp and pulled medially toward the tibia, in order to determine both the proper point for its lodgement in the tibia, and also the amount of force necessary to approximate it to the tibia. Forcible outward displacement of the foot and leg below the pseudarthrosis facilitates this task. In some cases, usually determined beforehand from a study of the roentgenograms, there may be interference with the medial displacement of the upper end of the fibula from the impingement of a mass of callus at the lateral surface of the pseudarthrosis, or from the lateral bowing or displacement of the fragments of the tibia. When approximation of the upper end of the fibula to the tibia cannot be obtained without the use of undue force, it is necessary to perform a partial osteotomy of the fibular shaft lower down, and produce a greenstick fracture which will allow it to be bent inward until contact with the tibia is obtained.

The fusion of the fibular shaft to the tibia is made by lifting up a flap of cortical bone on the lateral surface of the upper end of the tibia, and excavating a bed underneath of sufficient size to lodge the end of the fibula (Fig. 2-C). Bone chips may be packed in

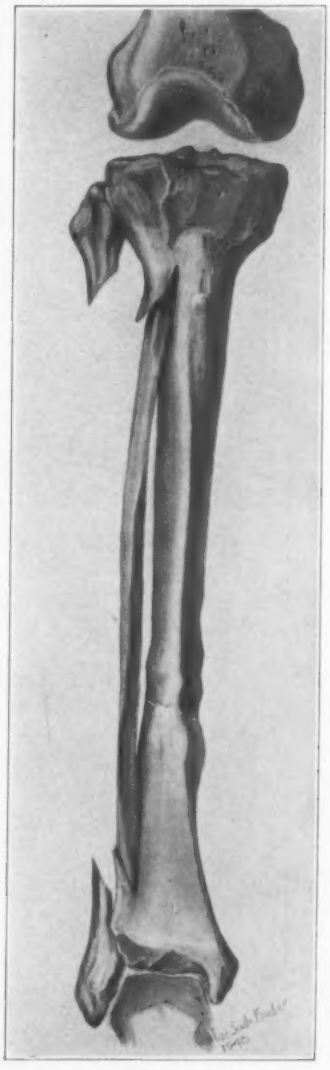

FIG. 1

Diagrammatic representation of completed operation.

and about the point of junction to make union more certain. Whether or not some form of metallic fixation should be employed depends upon how much tendency there is for the fibula to spring away from the tibia. In the case of an adult, because of the rigidity of the fibula, this is a wise precaution. The simplest method of fixation is a screw passed through the fibula into the tibia until its threads engage the opposite cortex.

Following fixation of the fibula to the tibia, the wound is closed. The muscle flap is replaced in its original position and its edges are sutured to the adjacent fascia. The common peroneal nerve is allowed to drop back into its original bed and the fascia is closed. The skin edges are sutured, following which the leg is carefully supported and a plaster casing applied, extending from the toes to the upper thigh.

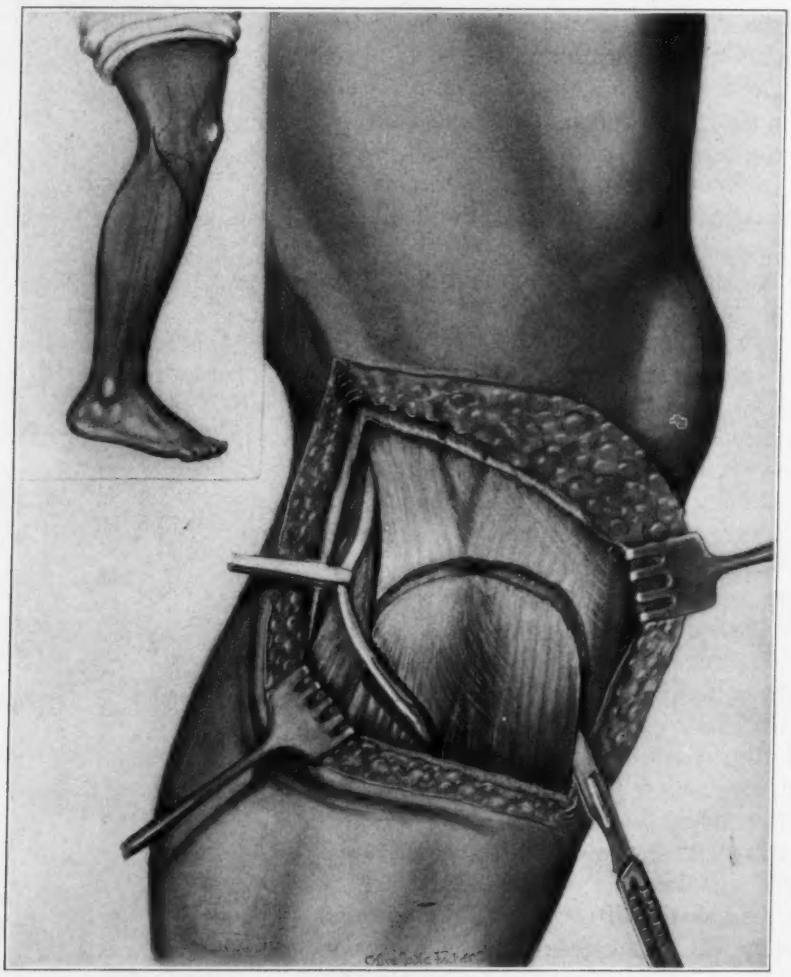

FIG. 2-A

Transplantation of upper end of fibula. Incision and separation of upper muscle flap.

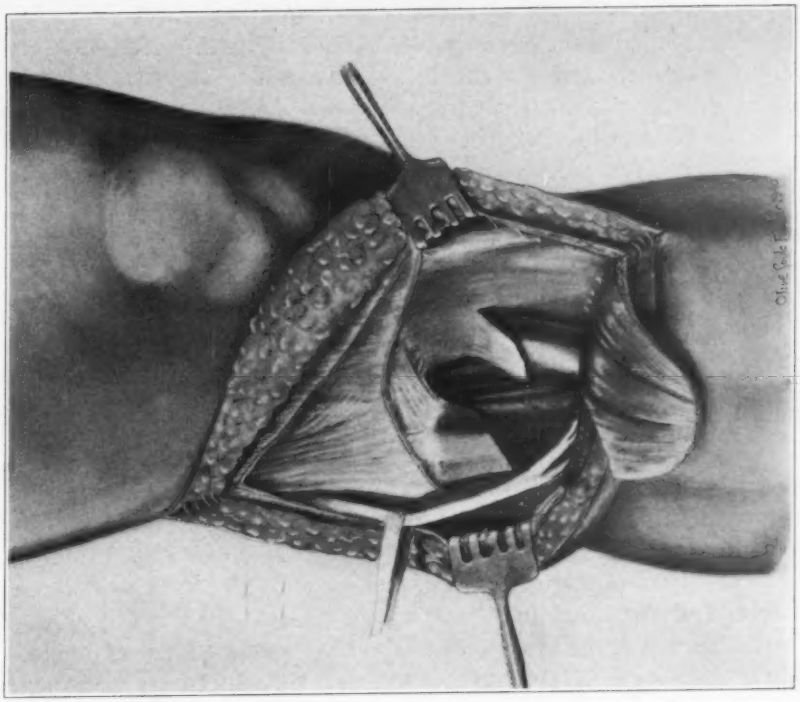

FIG. 2-C
Transplantation completed.

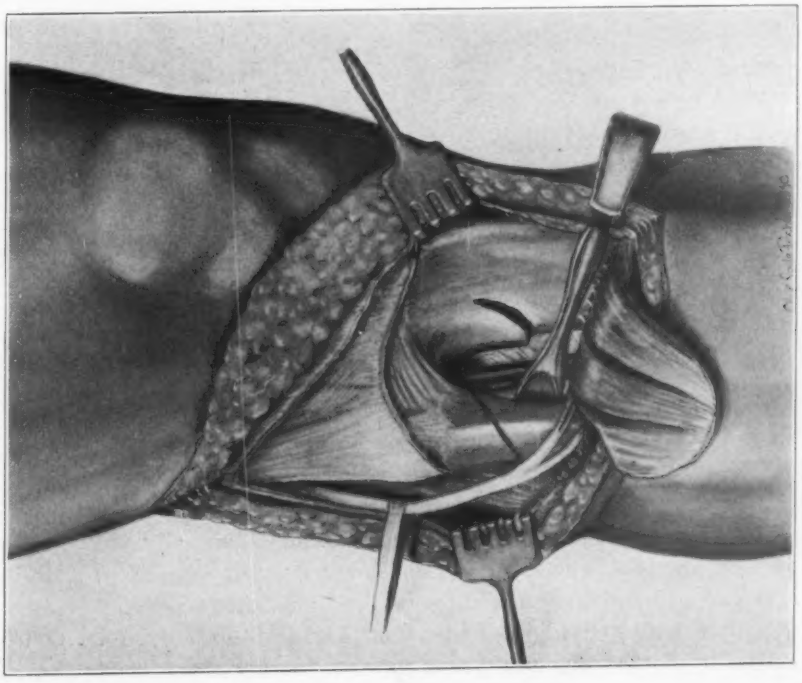

FIG. 2-B
Exposure completed preparatory to transplant.

Second Stage of Operation (Lower End)

The second stage of the operation should usually be delayed for about four weeks, or until the union of the upper end of the fibula with the tibia is secure. The aim is to produce a synthesis of the lower portion of the fibular shaft with the tibia, just above its point of junction with the latter. This operation is simple and requires no long description. With a tourniquet about the thigh, an incision about five inches long is made in the long axis of the limb over the anterior surface of the lower third of the leg at a point about midway between the tibia and fibula. The fascia is opened, freed from the underlying muscles, and retracted widely enough on either side to expose the fibula and tibia (Fig. 3-A). The shaft of the fibula is exposed subperiosteally, and divided with an osteotome in an oblique plane from below upward and outward, beginning just above the tibiofibular junction. The lateral surface of the lower portion of the tibia is exposed and, working outward with a blunt instrument from this point and inward from the region of the fibula, an opening is made between the interosseous membrane and the muscles lying anterior to it. The lower end of the fibular shaft is pulled through this opening and approximated to the lateral surface of the tibia. A flap of cortex is then split away from the lower end of the tibial shaft and a hole excavated behind it at the proper level, in which the lower end of the fibula can be securely lodged (Fig. 3-B). The incision is closed in layers, and a plaster casing is applied, extending from the toes to the upper thigh.

It is considerably easier to form the junction between the lower end of the fibula and the tibia than at the upper end, and it has been necessary to employ metallic fixation in only one instance. It should be pointed out, however, that in four out of five of the cases of congenital pseudarthrosis there was a pseudarthrosis of the fibula as well as of the tibia, and in these the second stage of the operation was atypical. The pointed lower end of the upper fragment was inserted in a hole in the upper end of the distal tibial fragment. Because of the shortness of the fibular fragment, some difficulty was encountered in approximating the bones. In one case (Case 6), the fibula pulled out of the tibia and approximation of the bones was lost. In this case a second operation was performed and osteosynthesis completed by the use of sliver grafts, layed in contact with the fibula and tibia, and held in place by the closure of the periosteum and muscles.

AFTER TREATMENT

Complete immobilization in plaster was employed in these cases for varying periods of months. Union of the fibula to the tibia usually was solid in from six to eight weeks after the operation. Generally at the end of about three months, a walking stirrup of steel was incorporated in the plaster, and weight-bearing on the affected limb was encouraged. As long as there was a chance of union of the tibial pseudarthrosis, complete immobilization in plaster was continued, in some instances up to one year.

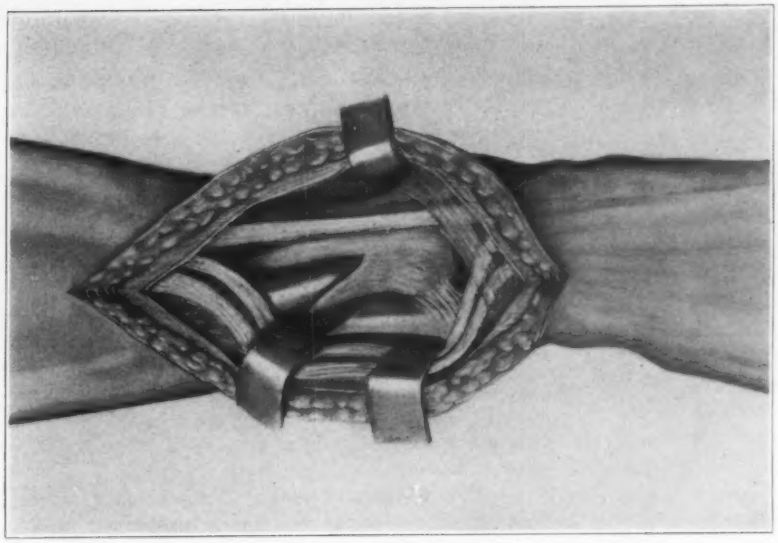

FIG. 3-B

Transplantation of lower end of fibula.

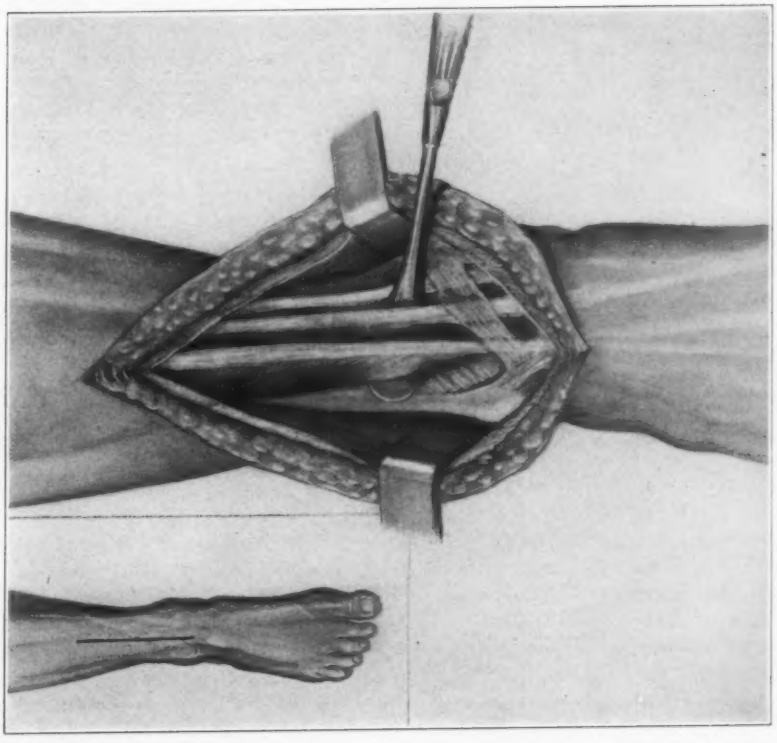

FIG. 3-A

Fig. 3-A: Exposure preliminary to transplantation.

Fig. 3-B: Transplantation completed.

When there was loss of substance of the tibia and union at this point could not be expected, a double upright brace, with sole plate, knee joint, and a laced leather cuff about the lower leg, was generally employed. Weight-bearing in this was encouraged, and the patients were instructed to get rid of crutches. At a later time a bone-grafting operation was performed and union promptly resulted.

CASE REPORTS

CASE 1. A. N. A female, aged thirty-five years, on December 23, 1926, sustained a compound comminuted fracture of the bones of the right leg at the junction of the middle and lower thirds. After débridement and a large loose fragment of bone had been removed, the wound healed by granulation without serious infection, but, because of loss of bony substance, there was failure of union. On October 20, 1927, an attempt was made to obtain union by the use of multiple bone chips and an osteoperiosteal graft, but this resulted in failure. On July 6, 1928, a massive bone graft, eight inches long, was removed from the opposite tibia and inlayed across the line of fracture. At the end of five months this operation appeared to be successful, but later absorption of the graft occurred, and the pseudarthrosis was reestablished at the old level.

It was decided to perform a two-stage side transplantation of the fibula. The first operation was performed at the Massachusetts General Hospital on September 19, 1929. With considerable difficulty and hemorrhage, as the simplified technique previously described had not yet been developed, the upper end of the fibula was transplanted into the upper end of the tibia. It was secured by the insertion of three steel screws and immobilization in plaster. There were no complications, and at the end of forty days the second stage of the operation was done, and the lower end of the fibula was transferred into the tibia. Plaster fixation was continued for three months when a brace was fitted. The roentgenographic examination at this time showed union of both ends of the fibula with the tibia and the beginning of union of the tibial fragments at the point of pseudarthrosis. One year after the last operation there was solid union of the tibia; the woman was walking normally, and had resumed work as a domestic. There was good alignment and excellent function of the knee and ankle.

CASE 2. M. D. A female, aged twenty-four years, was admitted to the Massachusetts General Hospital in February 1929, with a history of a fracture, probably compound, of the left tibia in childhood. Infection developed, and there was a draining wound until five years previous to admission, when, after an operation was performed, the wound healed. One year before admission an abscess developed in the scar and ruptured spontaneously with the discharge of a fragment of bone. After several weeks, the wound healed and had remained closed for ten months. The leg had always been deformed and weak, and had required the use of a brace, but for the last four years she had been able to bear full weight on it with perfect comfort.

Examination showed marked shortening and outward bowing of the left leg with a long, broad, thin scar on the anteromedial surface. Definite abnormal mobility could be demonstrated at the middle of the leg. The roentgenographic examination showed an ununited fracture of the tibia with an enormously hypertrophied fibula.

In February it was decided to excise the pseudarthrosis, to attempt to lengthen the leg by a Z-shaped osteotomy, and later to correct the pseudarthrosis by a bone transplant. Kirschner wires were inserted at the upper and lower ends of the tibia, and skeletal traction and countertraction were applied. The lengthening proceeded satisfactorily and about two inches were gained, but the ends of the fragments projected anteriorly and broke through the overlying skin. On April 17, 1929, the pins were removed and a plaster casing applied. The wound on the anterior surface drained and several operations were performed to remove the projecting bone ends and obtain healing. On June 18 the patient was discharged with the leg in plaster.

She was readmitted September 11, 1929, still with an ununited fracture of the tibia and a granulating wound one inch in diameter. Operation was performed September 14, 1929, and a sequestrum removed. It was thought that a two-stage transplant of the fibula into the tibia could be done safely by blocking off the draining wound. The first stage of the operation was performed September 30, 1929, and the upper end of the fibula was transferred to the tibia. Considerable difficulty was encountered in establishing contact of the bones, because of the impingement of the fibula against the bowed tibia at about its middle. The fibula was held against the tibia with two steel screws. The leg was fixed in plaster. Recovery was uncomplicated and the patient was discharged October 12, 1929.

Readmitted January 30, 1930, the patient still had a draining wound over the middle of the tibia. The second stage of the operation was performed, and the lower end of the fibula was transferred into the tibia. She was discharged with the leg in plaster February 18, 1930.

The patient was readmitted October 11, 1930, because the upper end of the fibula had failed to unite with the tibia. On October 14, 1930, the point of the upper transplant was exposed, the metal screws were removed, and bone chips were packed about the synostosis. She was discharged November 4, 1930, with the leg in plaster.

The patient was readmitted October 24, 1933; she had been walking with a brace. The wound over the tibia had healed, but the upper end of the fibula and tibia had still failed to unite. On October 27, 1933, the shaft of the fibula was divided at the junction of the upper and middle thirds; the upper end of the distal fragment was implanted into the upper fragment of the tibia, and fixed with transfixion screws. She was discharged November 14, 1933, with the leg in plaster.

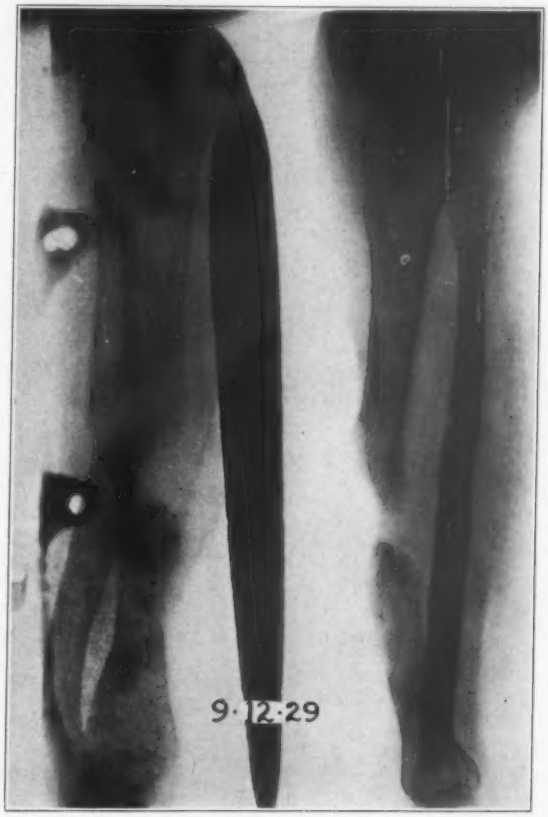

FIG. 4-A
Case 2

On August 20, 1934, the patient was readmitted. She had worn a plaster casing for four months following the last operation, and then had used a long leg brace. There was solid union of the fibula to the tibia, and the leg was stable. The wound on the anterior surface of the tibia was again discharging. The scar was excised, and a transfer of a pedicle skin flap was done with successful result. The patient was discharged September 28, 1934.

When the patient was last seen, November 17, 1936, there had been no further discharge from the leg wound, bony union was solid, and the patient was walking without brace support. There was good alignment, with shortening of one inch, and excellent function.

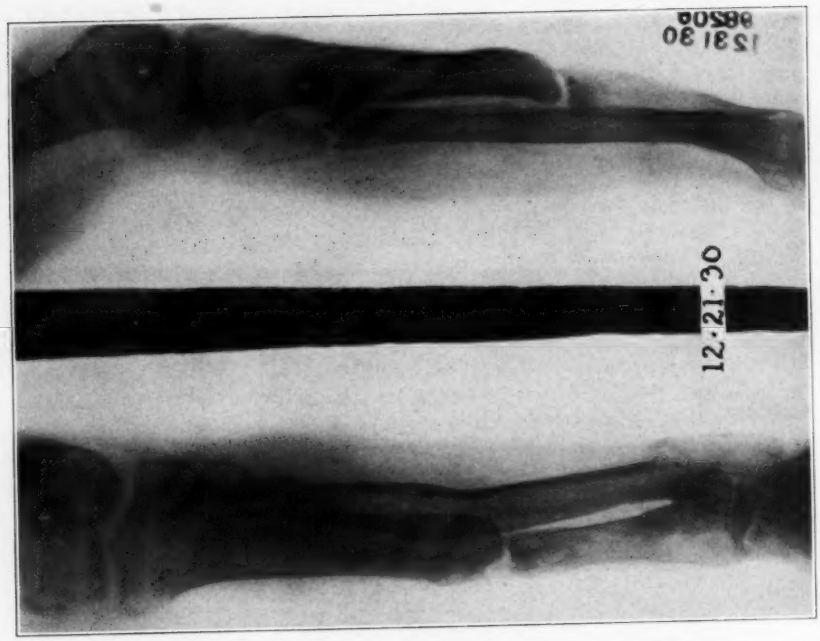

FIG. 4-C
Case 2

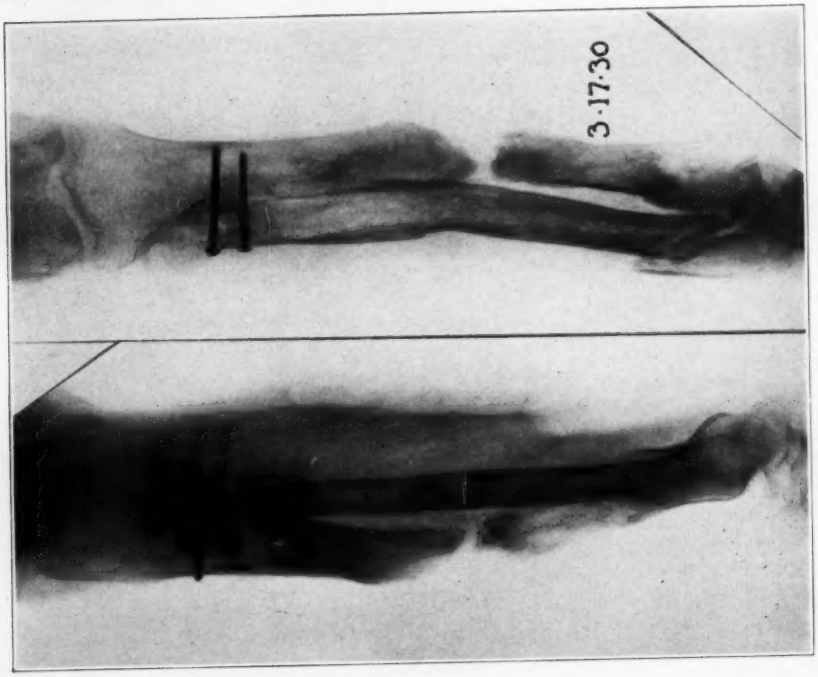

FIG. 4-B
Case 2

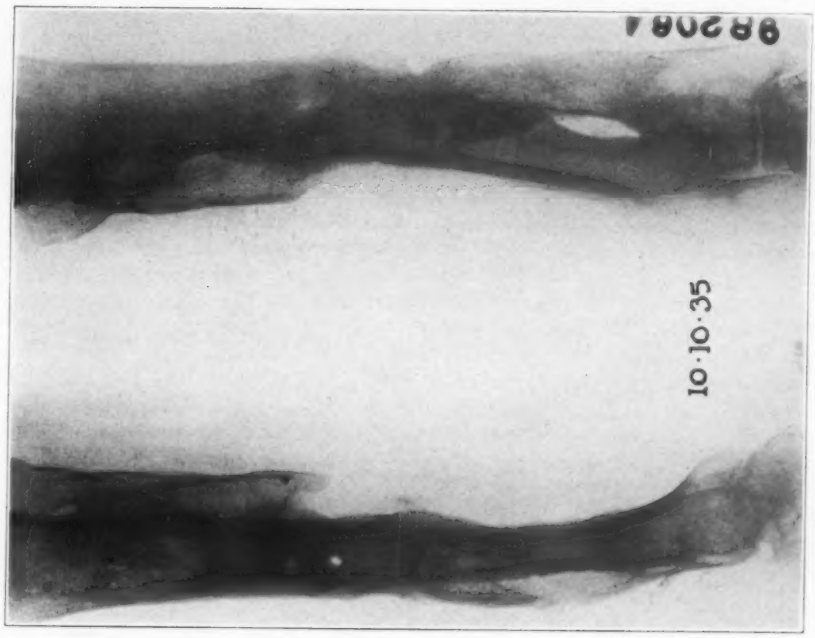

FIG. 4-E
Case 2

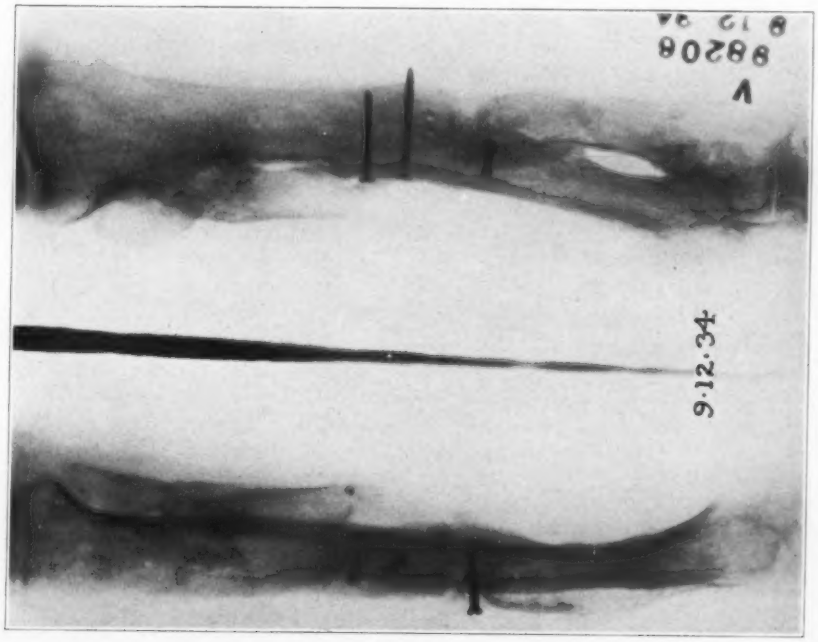

FIG. 4-D
Case 2

CASE 3. D. S. (No. H25–675). A male, aged eight years, was admitted to the Hospital for the Ruptured and Crippled in April 1937, with a diagnosis of congenital bowing of the left leg, pseudarthrosis of the tibia, and neurofibromatosis of von Recklinghausen. He had been followed continuously at the hospital since the age of nine months. At the age of three years an osteotomy of the tibia was performed, which was followed by failure of union. The leg was immobilized in plaster continuously for twenty months, at which time a transplant of a large bone graft from the right tibia into the left tibia by the inlay method was done. In January 1934, four months after the operation, there was union at the site of the old osteotomy, but absorption at the lower end of the bone graft, where a pseudarthrosis was developing. Weight-bearing in a plaster casing was permitted. In April 1935, the fibula was divided, the eburnated ends of the tibia excised, and the leg shortened so that the tibial fragments were approximated. They were fixed by the application of a large onlay graft from the opposite tibia, which was secured by the insertion of four steel screws. At the end of six months, the roentgenographic examination showed union at the old level of pseudarthrosis, but absorption at the upper end of the graft, where pseudarthrosis was developing. In December 1936, there was frank nonunion of the tibia, and the steel screws were removed by operation.

Examination in April 1937 showed a normally developed, active boy. The left leg was considerably atrophied, and there was abnormal mobility of the tibia in the lower part of the middle third, but the alignment was good. Inspection of the body showed numerous oval, brown pigmented areas on the skin of the trunk, characteristic of the multiple neurofibromatosis of von Recklinghausen.

A two-stage transplantation of the fibula into the tibia was done according to the technique previously described, with an interval of eight weeks between the two operations. All went well, and the roentgenographic examination in October 1937, six months after the operation, showed not only good union between both ends of the fibula and the tibia, but also the beginning of union of the tibial pseudarthrosis. In February 1938, ten months after the operation, this union seemed quite solid, and the patient was allowed to walk with the aid of a long leg brace.

In April 1938, without permission, he walked without his brace and fell, refracturing both fibula and tibia at the junction of the lower and middle thirds. There was no disalignment of the bones and he was treated by immobilization in plaster. The fibular fracture united rapidly, but union of the tibia was slow. Finally, in January 1939, four slender grafts from the opposite tibia were implanted under the periosteum, following the technique described by Hallock. Weight-bearing in a plaster casing was permitted at the end of two months. In December 1939, there was solid union with dense bony reparative tissue about the old fracture site, and the boy was allowed to bear weight in his brace.

When last seen in July 1940, he was getting about actively; the leg was straight and solid, with good function of the knee and ankle, and shortening of two centimeters.

CASE 4. E. G. (No. H17–287). A female aged four years, was admitted to the Hospital for the Ruptured and Crippled in November 1937, with a diagnosis of congenital pseudarthrosis of both bones of the right leg and multiple neurofibromatosis of von Recklinghausen. The child was first seen by the author in November 1934, at the age of eighteen months, because of marked bowing of the bones of the right leg. Roentgenographic examination showed a pseudarthrosis of the tibia at the junction of the middle and lower thirds, and a pseudarthrosis of the fibula at a level one centimeter lower. There was anterior and lateral bowing, and a suggestion of cystic change in the lower end of the upper tibial fragment. The bowing was corrected under anaesthesia, and a plaster casing was applied. In March 1935, there was abnormal mobility at the seat of the fracture. An operation was performed, exposing the ends of the fragments, and multiple drill holes were made in them with a fine drill. The ends of the fibular fragments were approximated and tied together with silk. The leg was immobilized in plaster constantly until the present admission, and weight-bearing was encouraged.

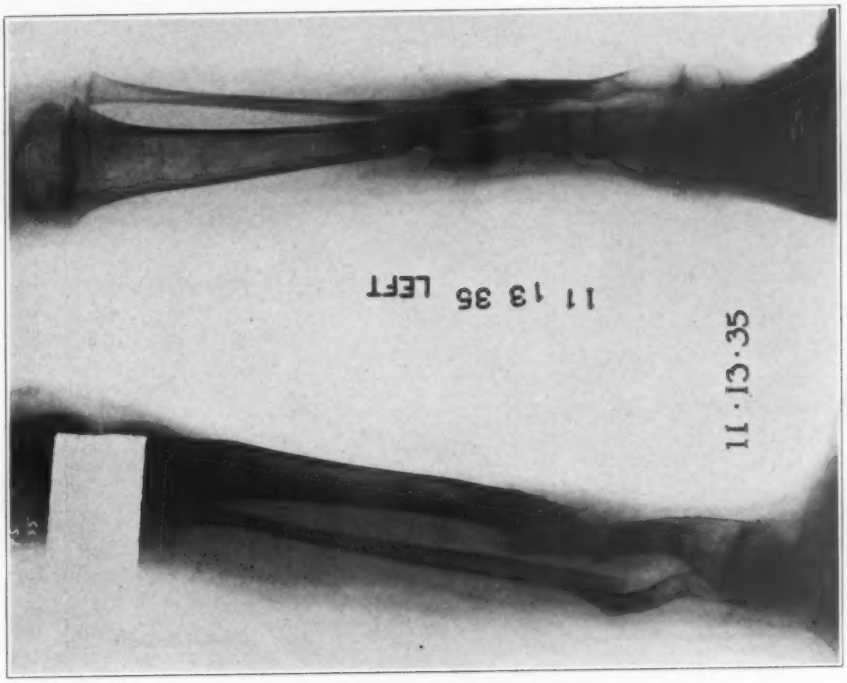

FIG. 5-B
Case 3

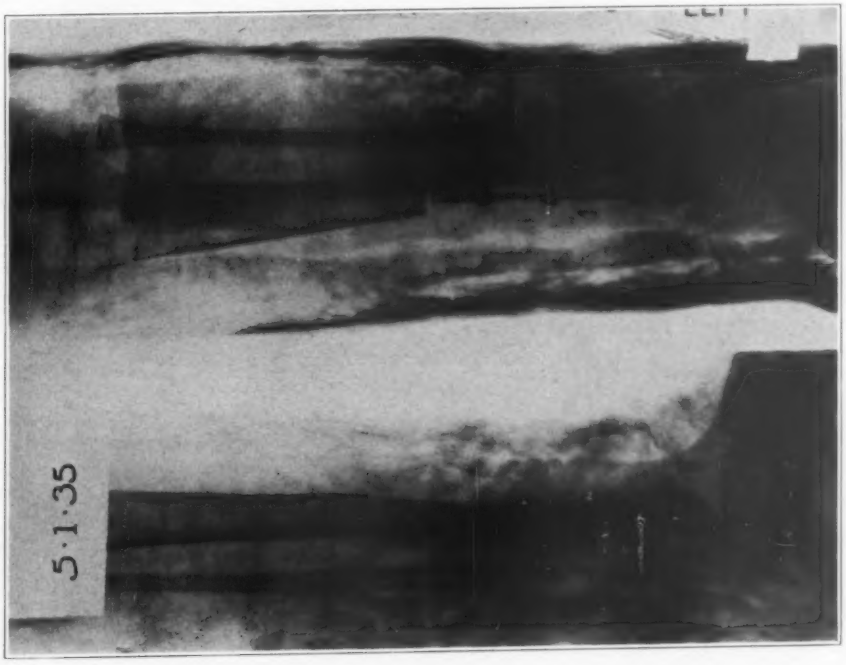

FIG. 5-A
Case 3

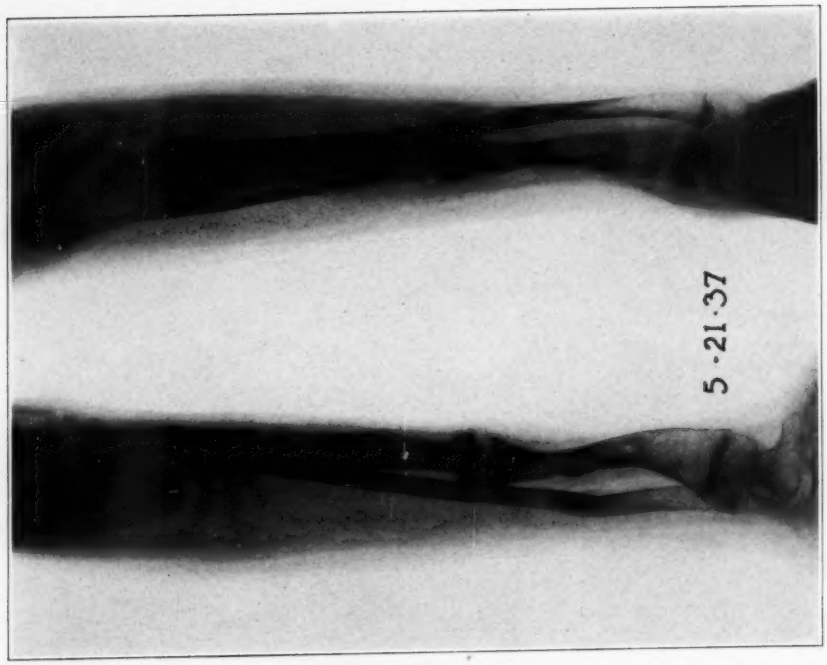

FIG. 5-D
Case 3

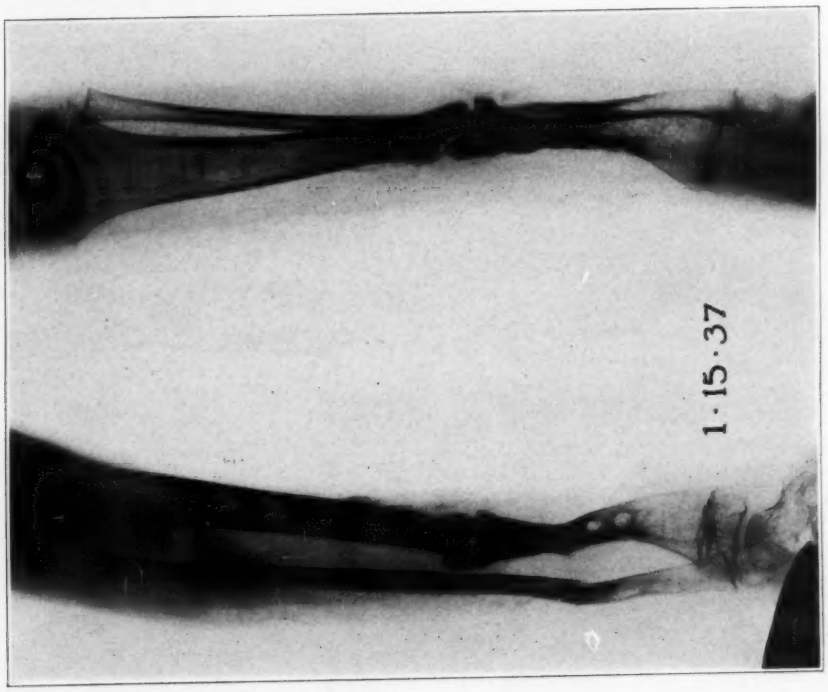

FIG. 5-C
Case 3

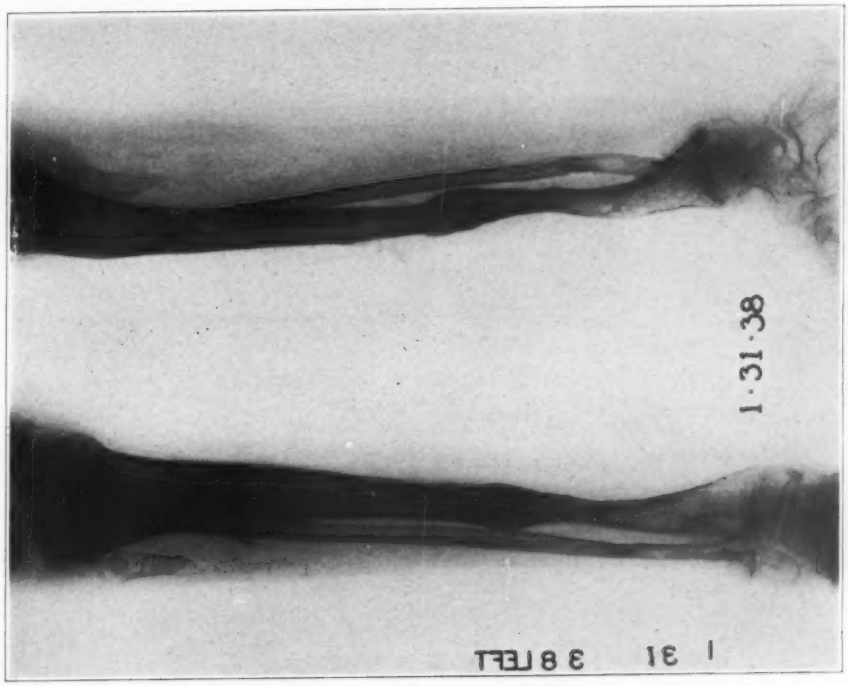

FIG. 5-F
Case 3

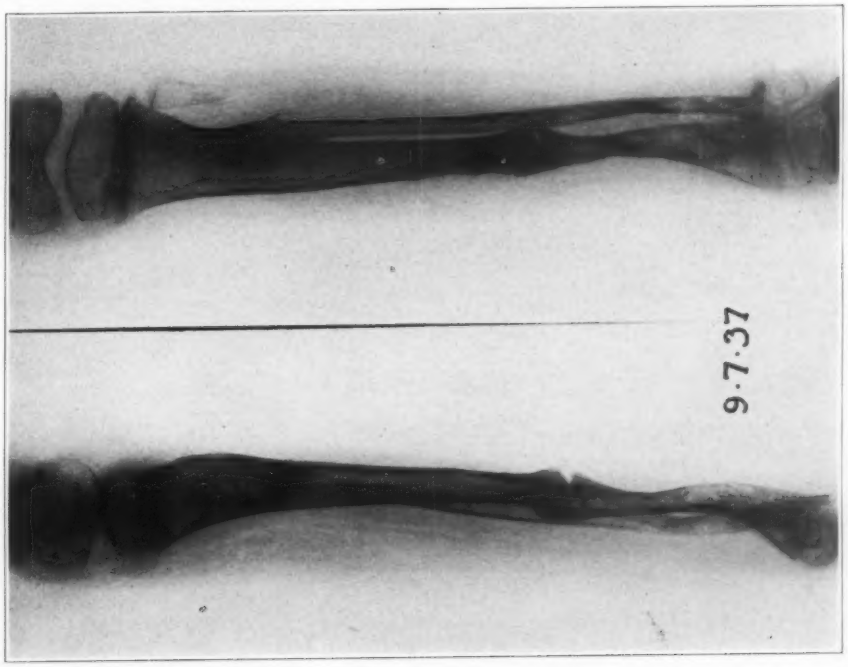

FIG. 5-E
Case 3

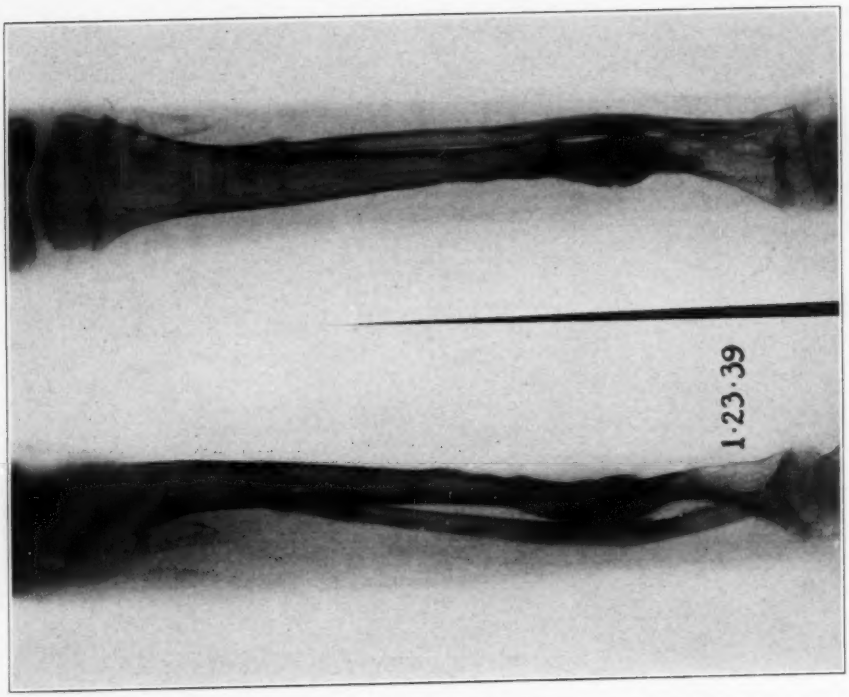

FIG. 5-H
Case 3

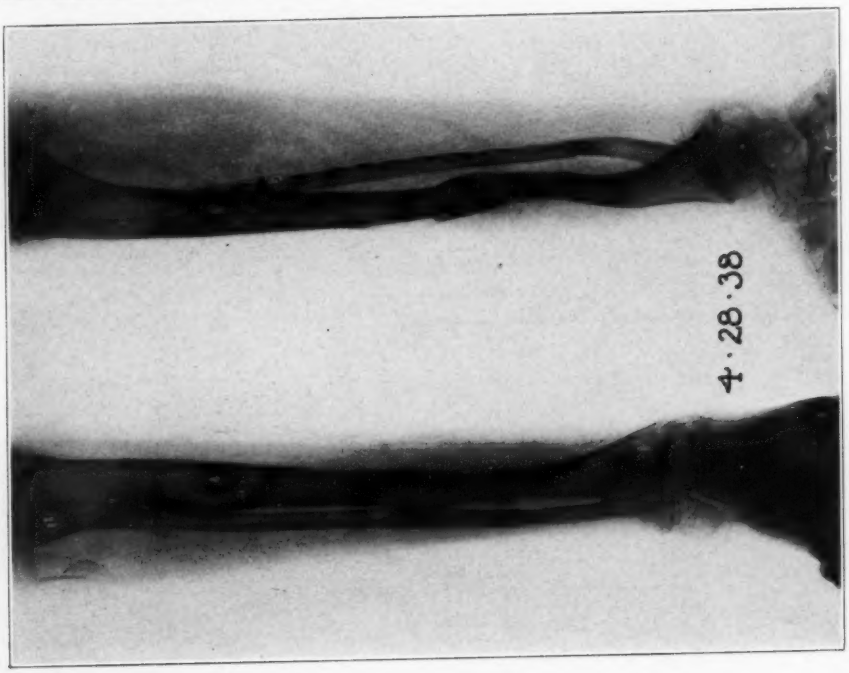

FIG. 5-G
Case 3

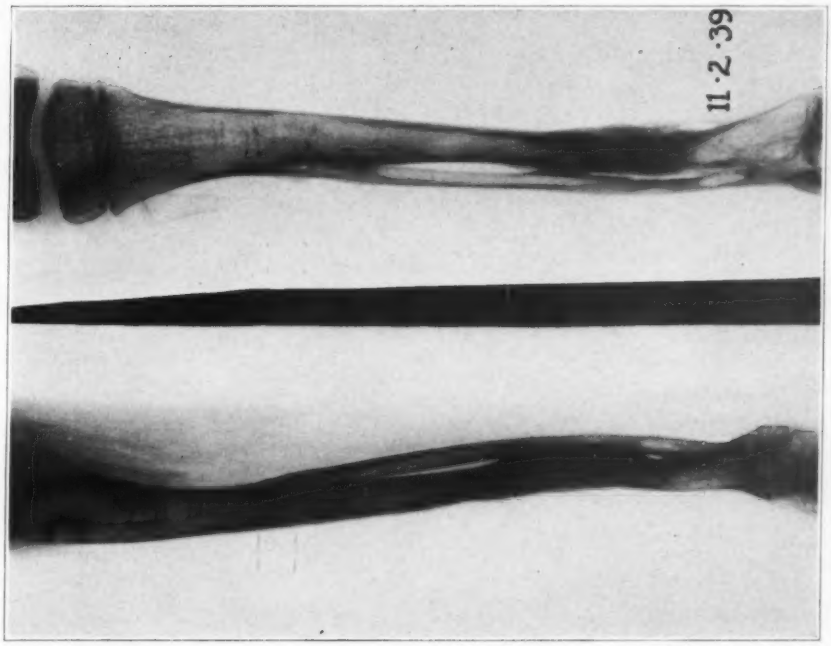

Fig. 5-J
Case 3

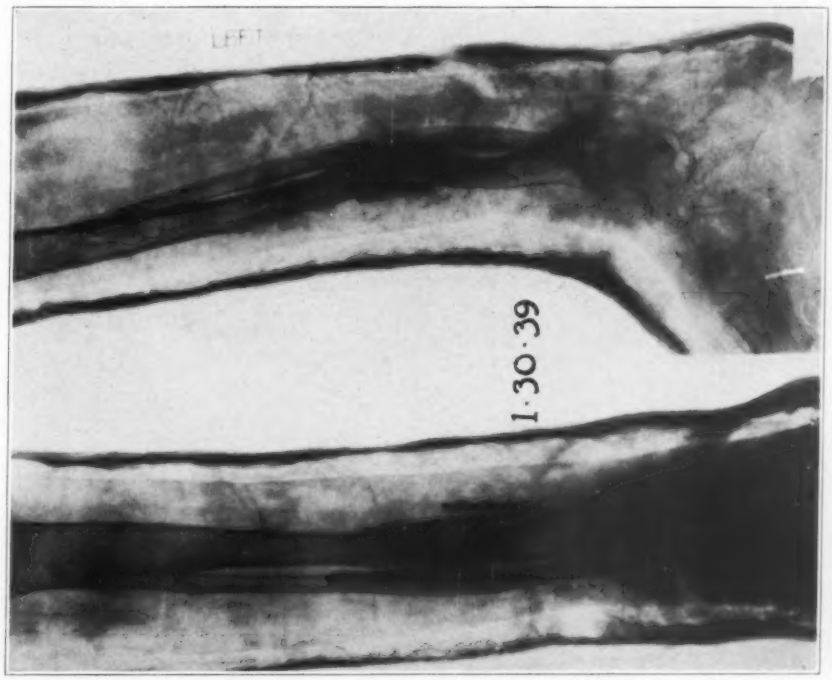

Fig. 5-I
Case 3

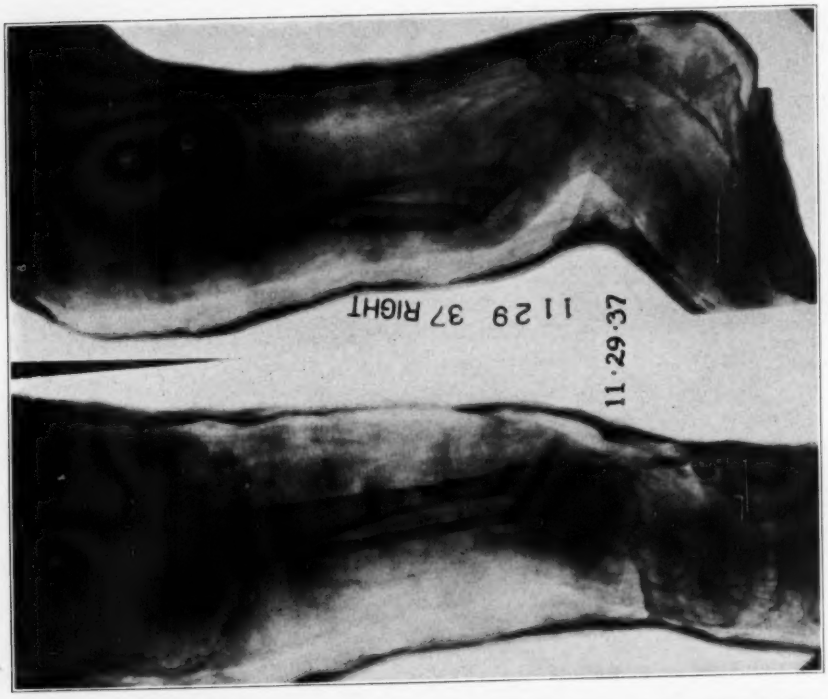

FIG. 6-B
Case 4

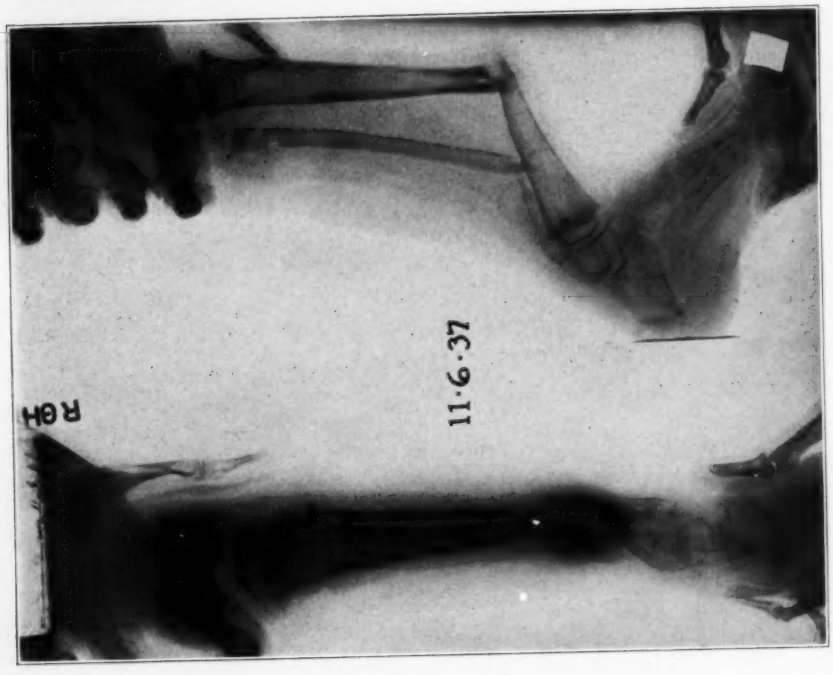

FIG. 6-A
Case 4

Examination at this time showed marked anterior bowing of the bones of the leg with beginning tendency to ulceration of the skin over the sharp bony prominence, and abnormal mobility at the seat of fracture. Several small oval pigmented areas, characteristic of von Recklinghausen's multiple neurofibromatosis, were discovered on the skin of the trunk, but no family history of this condition could be elicited.

On November 26, 1937, both ends of the upper fragment of the fibula were transplanted into the tibia at the same time. The upper end was transplanted in the manner previously described; the pointed lower end extended only one centimeter below the pseudarthrosis and had to be lodged in a hole made in the upper end of the lower fragment. At the same time the sharp projecting ends of the tibial fragments were trimmed away. The leg was immobilized in a plaster casing.

Convalescence was uneventful, and roentgenographic examination in September 1938, showed both ends of the fibula united to the tibia with considerable hypertrophy of the fibula. There was no evidence of union at the point of pseudarthrosis, although by clinical examination the leg appeared quite solid. On December 9, 1938, the seat of fracture was exposed, and the tibial fragments were found to be united. The sharp apex of the angulated tibia was excised. Two bone grafts about two inches long and one-fourth inch wide were removed from the opposite tibia and layed on either side of the tibia under the periosteum. The leg was fixed in plaster. The girl made a normal recovery from the operation. In June 1939, the condition was satisfactory. The union appeared strong both clinically and roentgenographically.

When last seen in March 1940, she was getting about well in her brace. The deformity of the bones of the leg was not excessive, and there was shortening of two and five-tenths centimeters.

CASE 5. P. C. (No. H13–934). A male, aged two years, was admitted to the Hospital for the Ruptured and Crippled in October 1934, with a diagnosis of congenital bowing of the right leg, pseudarthrosis of the tibia and fibula, and mental retardation. The child had first been seen at the hospital with this condition at the age of fifteen months. The leg had been continually immobilized in plaster for thirteen months without appreciable result. The roentgenographic examination showed marked bowing of the entire tibia and an ununited fracture of the fibula about half an inch above its lower end.

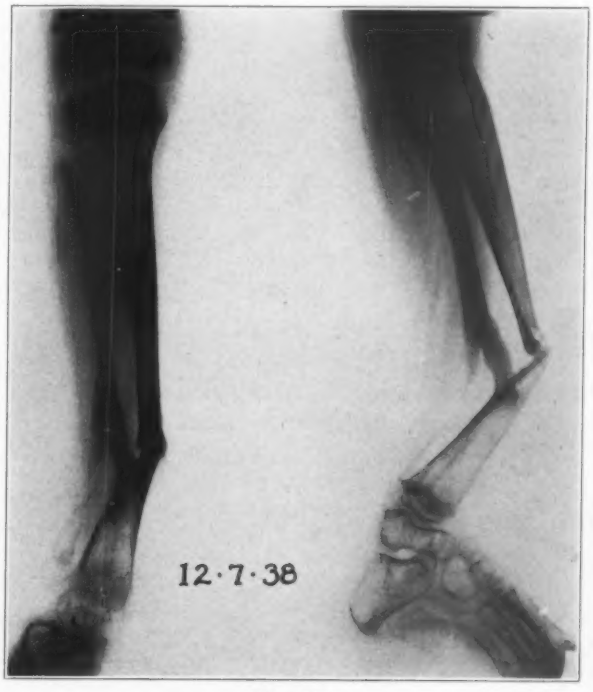

FIG. 6-C
Case 4

An operation was performed and the ends of the tibial fragments freed and stepped together with an overlap of three-fourths of an inch. The lower end of the upper fragment of the fibula was freed and transplanted into a hole in the

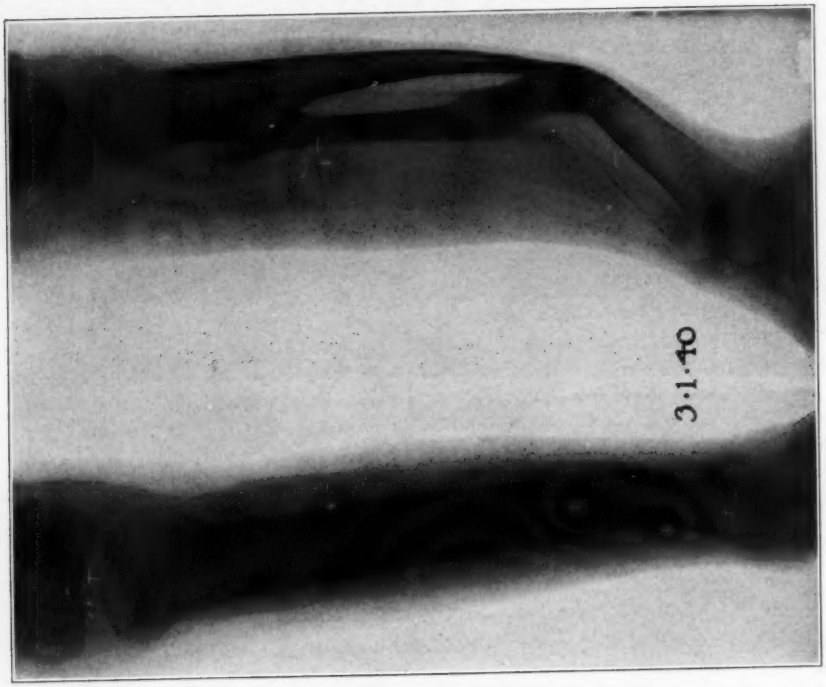

FIG. 6-E
Case 4

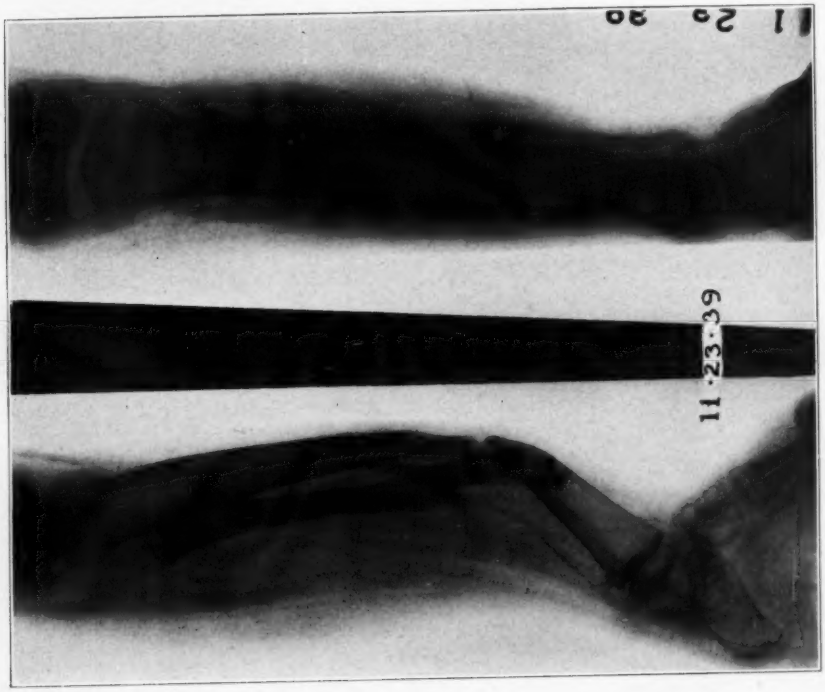

FIG. 6-D
Case 4

distal fragment of the tibia about one inch below the fracture, and a plaster casing was applied.

Six months postoperatively the roentgenographic examination showed that the fibula had united with the distal fragment of the tibia with anteromedial angulation, but the tibial fracture was still ununited. In April 1935, a second operation was performed in which a massive graft, three and five-tenths inches long, was removed from the opposite tibia, applied to the point of pseudarthrosis, and fixed with two steel screws.

The leg was immobilized in plaster until October 1935, at which time the roentgenographic examination showed solid union, and a long leg brace was fitted. He did well and was followed in the Out-Patient Clinic. In January 1937, the screws were found to be loose, and were removed. In May 1937, he complained of pain in his leg and the roentgenographic examination showed there had been a refracture of the tibia at the level of the previous pseudarthrosis. A close-fitting plaster casing was applied and worn continuously until March 1938, at which time there appeared to be a definite pseudarthrosis of the tibia. It was decided to transplant the upper end of the fibula into the upper end of the tibia.

This operation was performed on March 5, 1938, in the usual manner except that in order to bend the upper end of the fibula far enough inward to meet the tibia it was necessary to perform a partial osteotomy of the fibular shaft, and produce a green stick fracture. The leg was immobilized in plaster until January 1939, at which time the roentgenographic examination showed not only firm healing of both ends of the fibula with the tibia, but also bony union of the tibial pseudarthrosis.

When last seen in May 1940, he was getting about actively in his brace, and there were no complaints. Roentgenograms showed good healing of the tibia with anterior bowing, but there appeared to be a line of separation between the lower end of the fibula and the tibia.

Case 6. M. D. (No. H14-907). A female, negro, aged five years, was admitted to the Hospital for the Ruptured and Crippled in January 1938, with a diagnosis of congenital bowing of the right leg and pseudarthrosis of the tibia and fibula. She had been followed at the hospital since the age of one year, at which time she was found to have marked anterior bowing of the right tibia with pseudarthrosis of the fibula. In February 1934, an osteotomy of the tibia was performed with correction of the bowing followed by plaster immobilization. In November 1934, she was recognized as having a frank pseudarthrosis of both bones of the leg, and a long leg brace was fitted. In May 1935, the eburnated ends of the tibial fragments were excised, and a massive graft three inches long and three-fourths of an inch wide, taken from the left tibia, was fixed by the insertion of two steel screws. The ununited ends of the fibular fracture were overlapped about one inch, and the leg was fixed in a plaster casing. The child made a normal recovery, but rapid absorption of the graft occurred, and, in December 1935, it was evident that the condition of pseudarthrosis had been reestablished.

She was readmitted to the hospital for transplantation of the fibula, and the first stage of the operation was performed in February 1938, according to the method previously described. The incision was extended downward sufficiently to permit removal of the screws. Recovery was complicated by necrosis of a portion of one skin flap, but this was trimmed away and the wound healed by granulation. The second stage of the operation was performed seven weeks after the first, and considerable difficulty was experienced in establishing contact between the short upper fragment of the fibula and the lower fragment of the tibia. An attempt was made to fix them together with a chromic suture, but later it was found that the ends had separated. In October 1938, there was firm union of the upper end of the fibula to the tibia, but complete loss of connection at the lower end and the pseudarthrosis persisted. At this time the region of the pseudarthrosis and the lower end of the upper fibular fragment were exposed. The latter was osteotomized about two inches above its lower end, which permitted its insertion into a hole in the upper end of the lower tibial fragment. At the same time four slender, match-stick grafts, each about three inches long, were removed from the opposite tibia

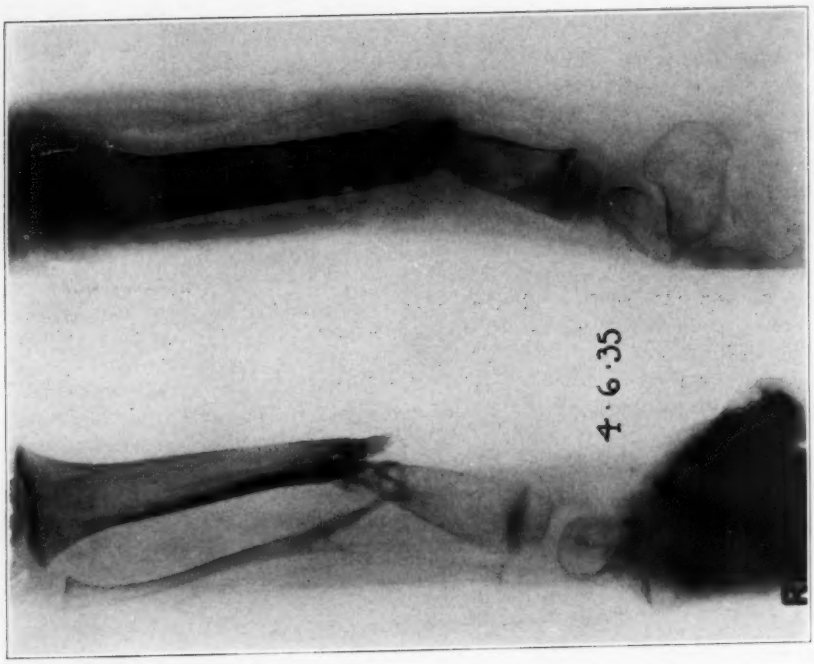

FIG. 7-B
Case 5

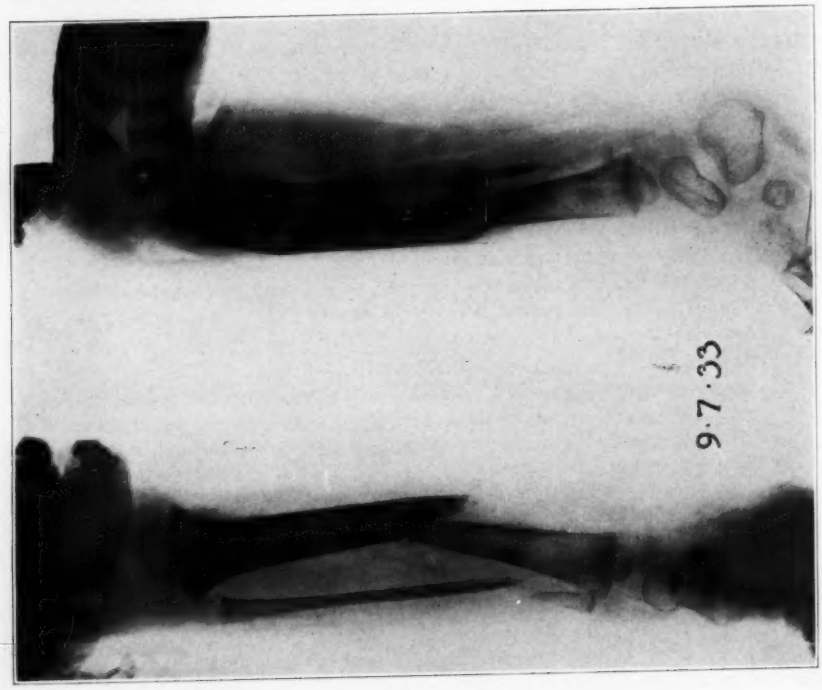

FIG. 7-A
Case 5

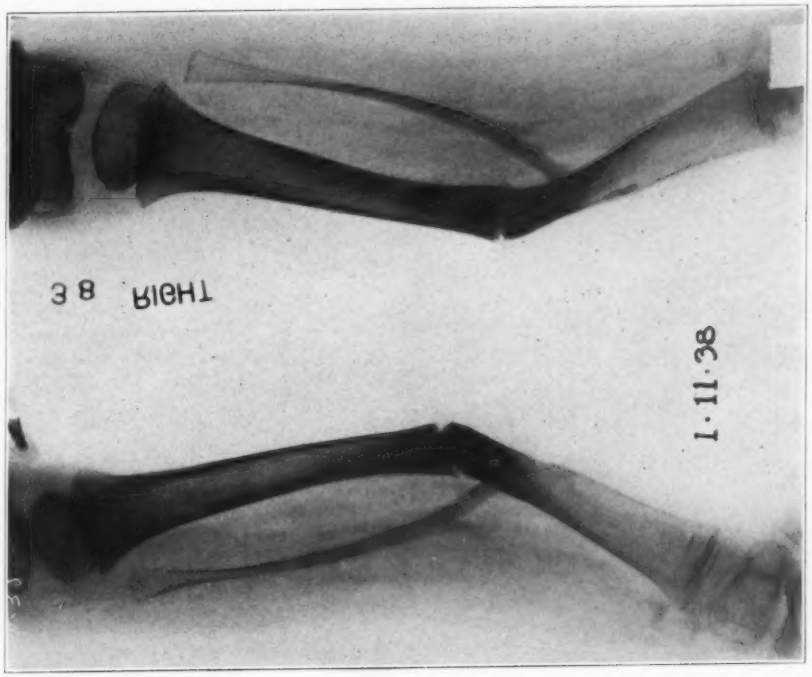

FIG. 7-D
Case 5

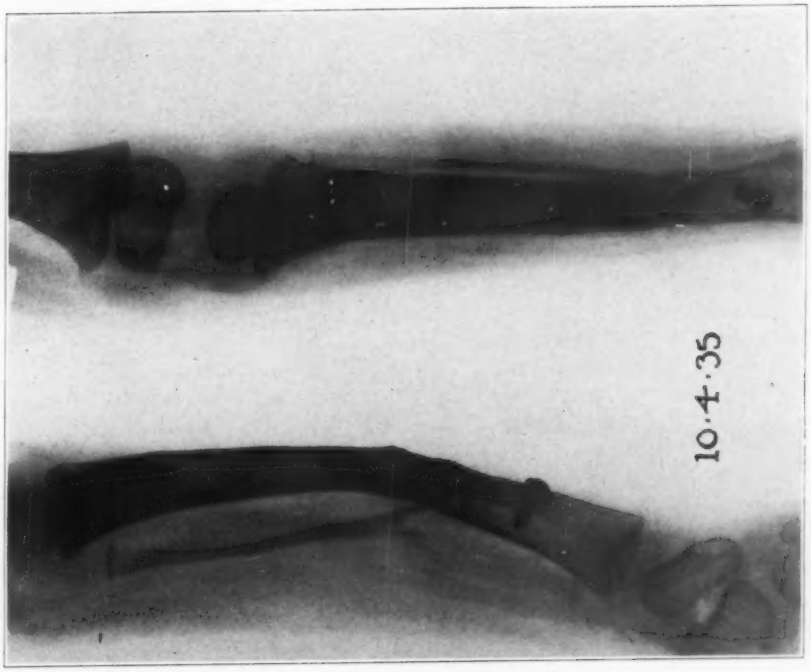

FIG. 7-C
Case 5

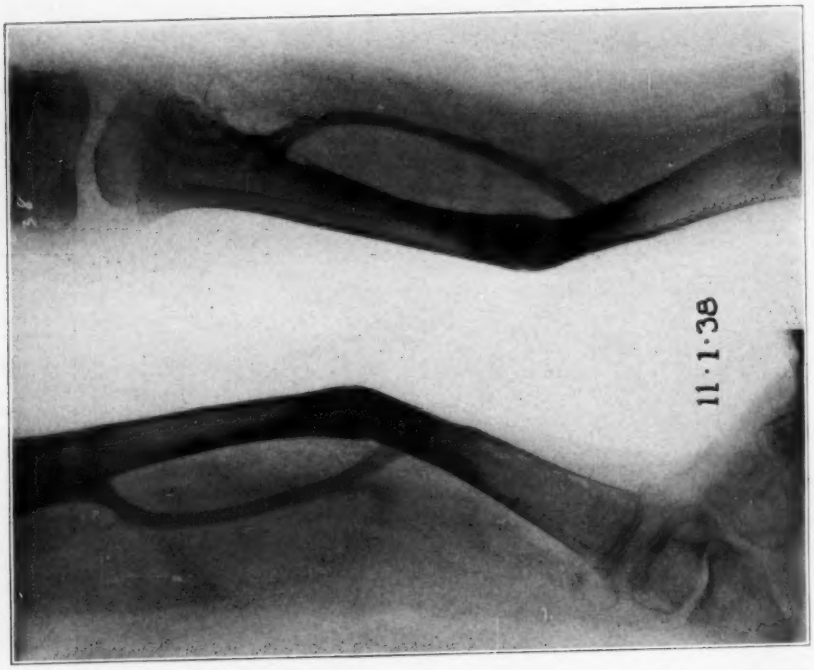

FIG. 7-F
Case 5

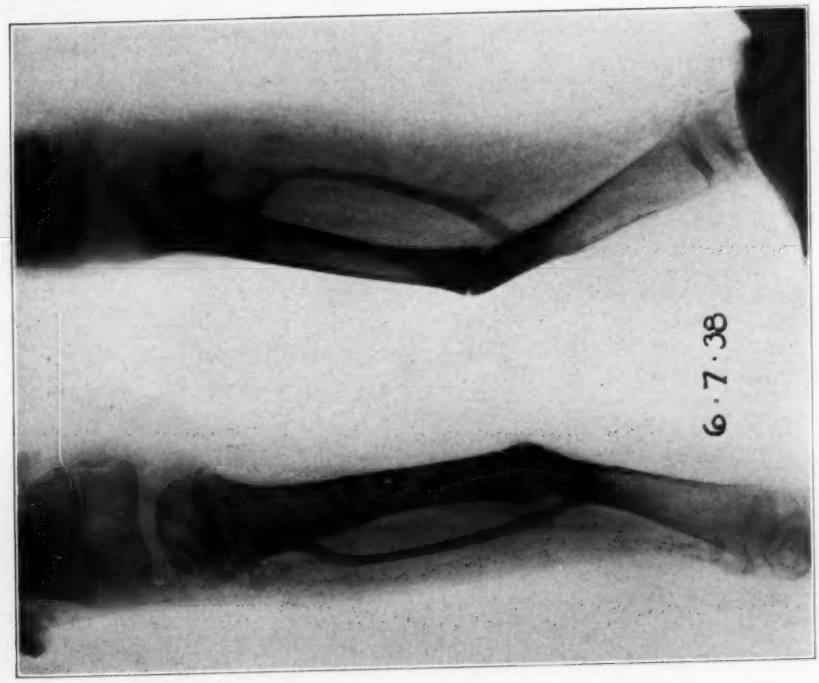

FIG. 7-E
Case 5

and laid under the periosteum about the point of the pseudarthrosis and at the junction of the fibular fragment with the tibia. The wound was closed and a plaster casing applied. Recovery was uneventful and two months later the roentgenographic examination showed a mass of new bone uniting the lower end of the fibula with the tibia. In November 1939, the fibula was found to be solidly incorporated in the tibia, and the tibial pseudarthrosis was also solidly united. At this time she was given a long leg brace and permitted to bear weight.

When last seen, in April 1940, she was getting about actively in her brace. The leg was straight with two inches of shortening. The union was solid on both clinical and roentgenographic examinations.

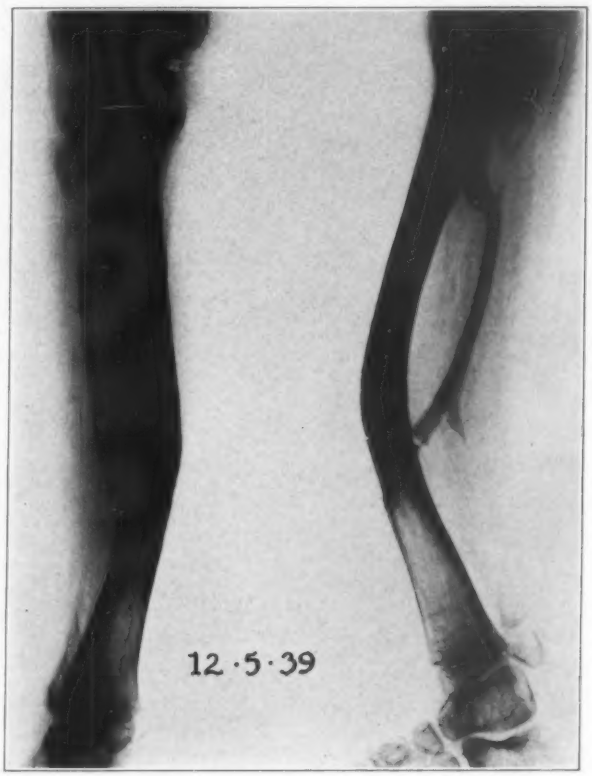

FIG. 7-G
Case 5

CASE 7. D. R. (No. H30-147). A male, aged six years, was admitted to the Hospital for the Ruptured and Crippled in November 1938, with a diagnosis of congenital bowing of the left leg, and pseudarthrosis of left tibia and fibula. According to the parents, the deformity had been present from birth, but the boy was able to use the leg normally. About twelve weeks previously, he had fallen from a chair and fractured the leg. A plaster casing was applied, but when this was removed there was no evidence of union. Upon examination marked deformity of the leg with anterior bowing and abnormal mobility without pain could be demonstrated at the junction of the lower and middle thirds. The roentgenographic examination showed an ununited fracture of the tibia with medial and anterior angulation, and an ununited fracture of the fibula at a slightly lower level.

It was decided to transplant the upper fragment of the fibula. On November 4, 1938, the first stage of the operation was performed with transplantation of the upper end of the fibula into the lateral tuberosity of the tibia in the manner described. The second stage of the operation was performed on December 8, 1938, and the lower end of the upper fragment of the fibula was fixed to the lower tibial fragment with a wire suture. Both operations were followed by immobilization of the leg in a plaster casing.

Both ends of the fibula united promptly with the tibia, and, in March 1939, there was evidence that the tibial pseudarthrosis was uniting. A walking plaster was used for fixation until March 1940, at which time he was given a long leg brace. At this time he had normal use of the leg and the roentgenographic examination showed solid union of the tibia.

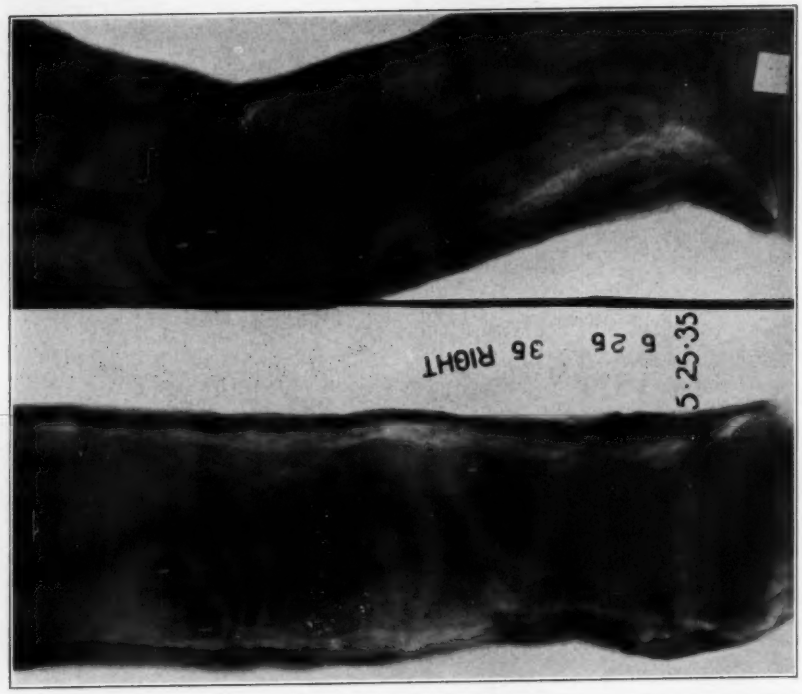

FIG. 8-B
Case 6

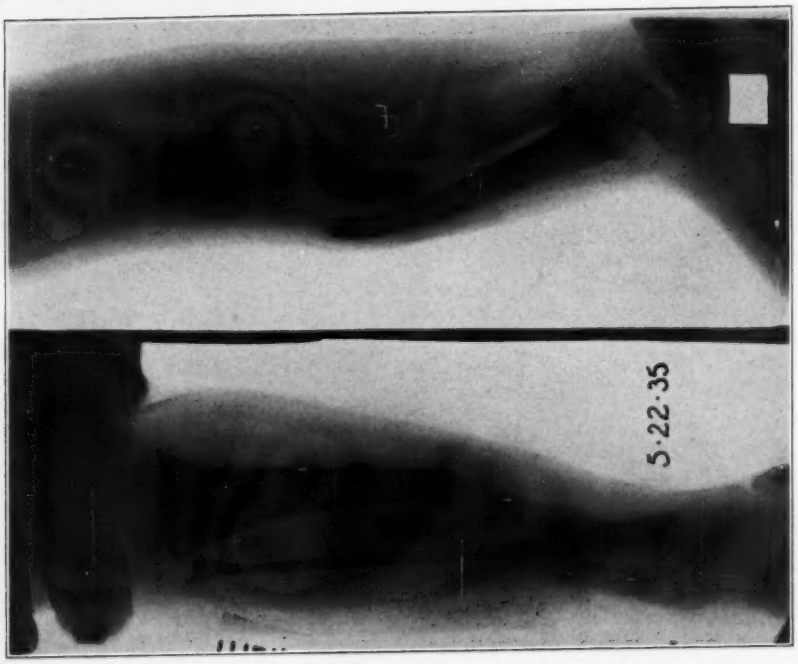

FIG. 8-A
Case 6

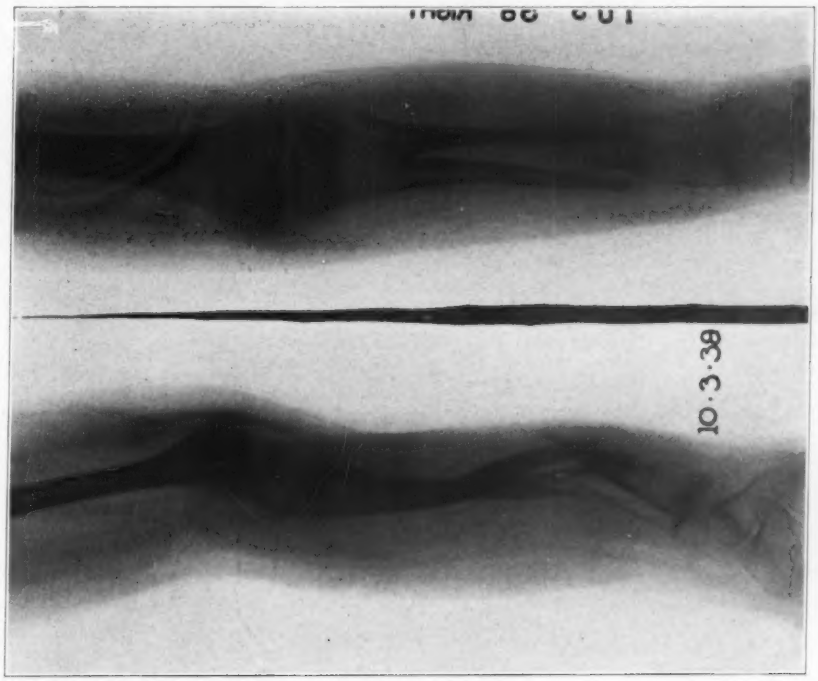

FIG. 8-D
Case 6

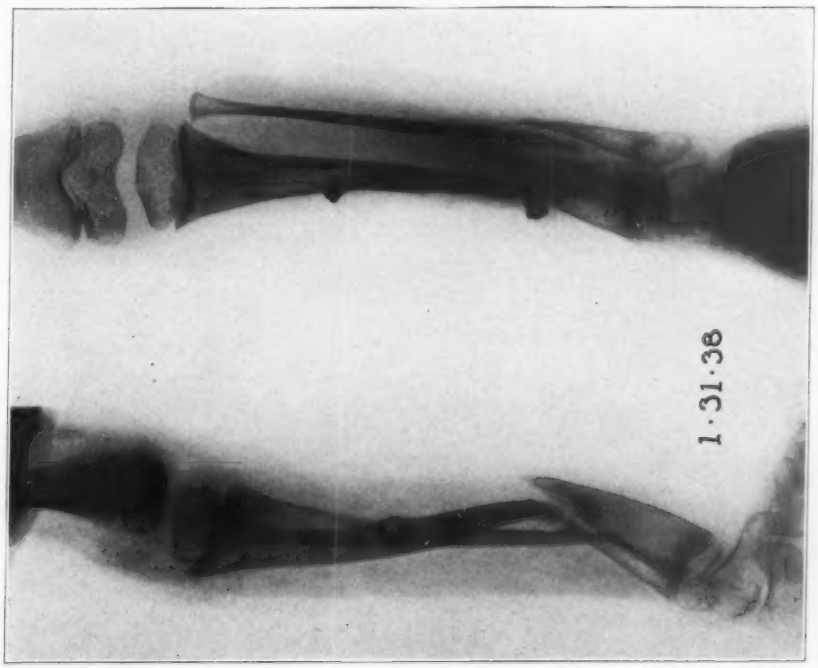

FIG. 8-C
Case 6

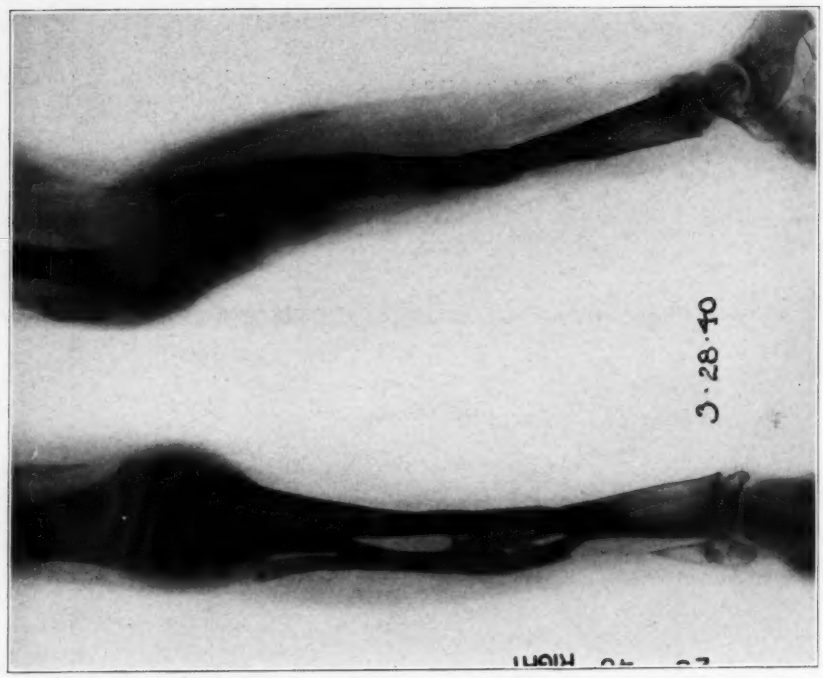

FIG. 8-F
Case 6

FIG. 8-E
Case 6

CASE 8. F. L. (No. H28-247). A male, aged forty-nine years, was admitted to the Hospital for the Ruptured and Crippled September 19, 1938, with a diagnosis of old, infected, compound fracture of both bones of left leg, and pseudarthrosis of the tibia. He had been injured in an automobile accident in June 1936. The fracture had been treated by skeletal traction, followed by a long period of immobilization in plaster. The wound healed after about four weeks. The facture failed to unite, and in January 1937, an operation was performed, probably a bone transplantation from the same tibia, which was followed by wound infection and suppuration. The wound drained until February 23, 1938, when an operation was performed and a sequestrum removed. The wound healed by granulation and was completely closed at the end of four months. At this time a long leg brace was fitted and weight-bearing was encouraged.

The examination at the time of admission showed good alignment of the leg, shortening of about three-fourths of an inch, and abnormal mobility in the middle third of the tibia. The roentgenograms showed a gap of nearly one inch between the ends of the fragments of the tibia, and considerable eburnation. The fibula had been fractured, but had united.

Because of the history of recent infection it was thought that a bone-grafting operation had little chance of success, and a two-stage transplantation was advised. The first operation was performed on September 21, 1938, and consisted of excising the cartilaginous surfaces of the upper tibiofibular articulation, and burying the upper end of the fibula in a bed dug out of the lateral tuberosity of the tibia. The second stage was performed on October 17, 1938, when the fibular shaft was divided in its lower third, and its lower end applied to the lower fragment of the tibia where it was fixed with a vitallium screw. The leg was immobilized in plaster until March 1939, when the patient was allowed to resume wearing his brace.

FIG. 9-A
Case 7

Solid union of both ends of the fibula with the tibia was obtained, but there was still slight mobility of the tibia at the point of pseudarthrosis, and he was not able to walk without his brace. There had been no recurrence of the infection, and it was considered safe to do a bone-grafting operation, which was performed on June 15, 1939. A bone graft, six inches long, was removed from the opposite tibia and applied to the ends of the fragments,

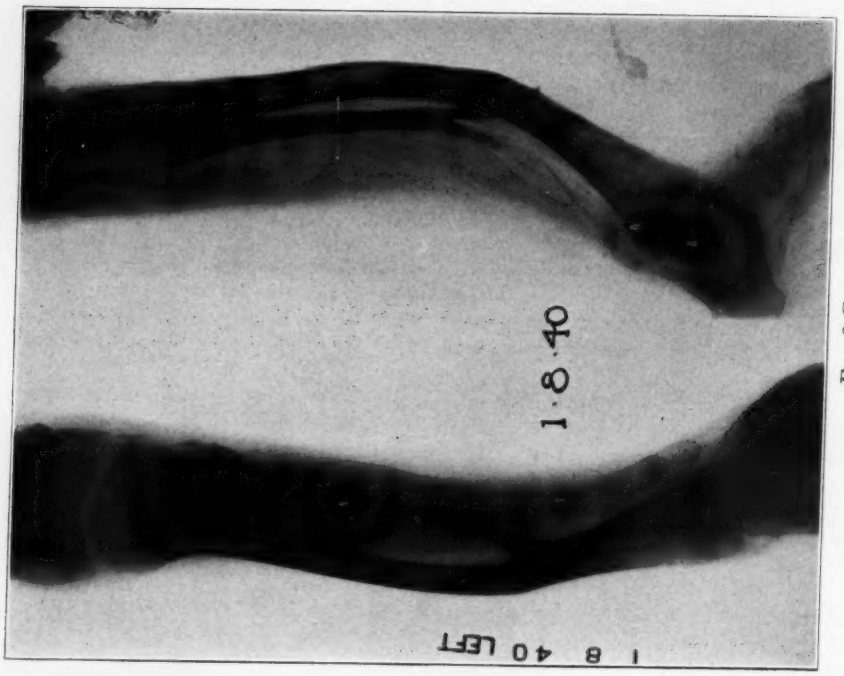

FIG. 9-C
Case 7

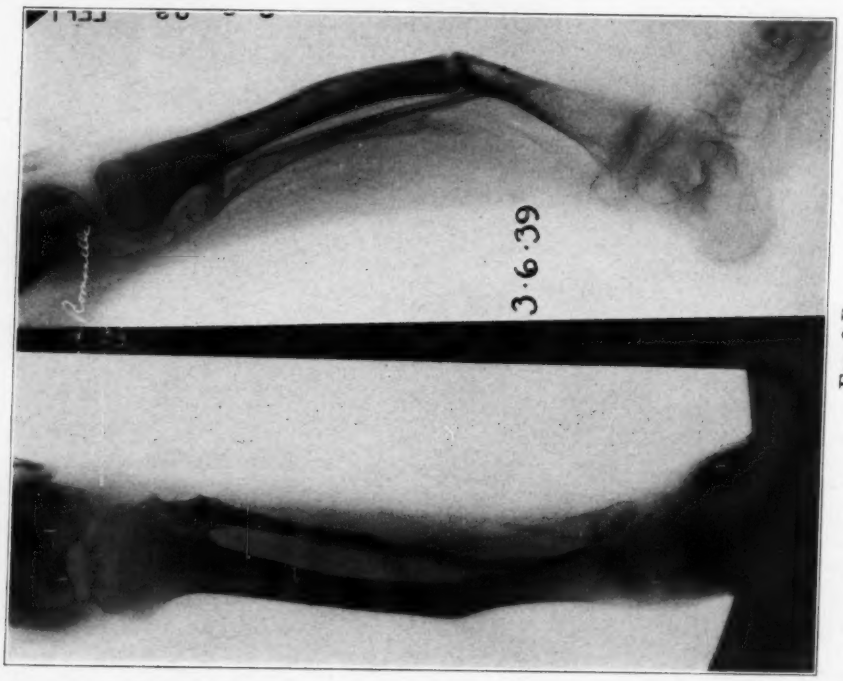

FIG. 9-B
Case 7

being fixed by the insertion of four vitallium screws. Recovery was complicated by a skin slough, about one inch in diameter, which was finally closed, except for a small persistent sinus, by the application of small pinch grafts. The leg was protected in a plaster-of-Paris casing, and later in a steel brace until January 1940, at which time the roentgenogram showed solid incorporation of the graft, and he was allowed to walk without support.

When last seen, in July 1940, he was walking without cane or other support, and there was solid union both clinically and roentgenographically. The leg was straight with shortening of three-fourths of an inch. There was still a small draining sinus on the medial surface which, on probing, led down to bare bone, and the roentgenogram suggested the presence of a small sequestrum in this region.

CASE 9. J. V. (No. H31-136). A male, aged thirty-nine years, was admitted to the Hospital for the Ruptured and Crippled March 17, 1939, with a diagnosis of infected fracture of the bones of the right leg, and pseudarthrosis of the right tibia. The injury occurred March 14, 1938, when he was knocked down by a motor car. The fracture was not compound, and he was treated in splints for one month, when a bone-plating operation was performed, and the leg immobilized in a plaster casing. Infection developed and at the end of three months the plate was removed. The fracture failed to unite, and in November 1938, a third operation was performed, and the fragments were fixed together with wire.

Examination at the time of admission revealed a suppurating wound, one inch in diameter, situated over the medial surface of the middle of the tibia, and abnormal mobility of the tibia at this point. The leg showed moderate lateral bowing, and there was shortening of three-fourths of an inch. The roentgenograms showed an ununited fracture of the tibia in its middle third with a number of turns of wire in the ends of the fragments, and a loose sequestrum.

On March 24, 1939, the sequestrum and wire were removed, the wound was packed open with vaseline gauze, and a plaster casing was applied. On April 22 the wound was clean and granulating, and it was considered possible to block it out of the field and proceed with a two-stage transplantation of the fibula into the tibia.

The first stage of the operation was performed on April 29 and the second stage on June 14, each time followed by the application of a plaster casing. No complication occurred, and the wound over the tibia was completely healed in September 1939. At this time the man was fitted with a long leg brace and allowed to bear weight. The roentgenographic examination indicated that union at the lower end of the fibula was firm, but at the upper end it was questionable. There was evidence of beginning union of the pseudarthrosis. In December 1939, the roentgenograms showed solid union of the tibia and the brace was discontinued. When last seen in March 1940, he had no complaints and was walking with full weight on the leg. There was slight lateral bowing, but good function of the knee and ankle.

DISCUSSION

The point of chief interest that emerges from the study of the cases was the high proportion in which spontaneous union of the tibial pseudarthrosis followed promptly after the union of the fibula to the tibia. This occurred in six out of the nine cases. In two of these it was found advisable later to reinforce the union with sliver bone grafts, in one (Case 3) because of refracture, and in the other (Case 4) because of the delicacy of the bones, but this did not alter the fact that union had resulted. In two of the three cases in which union did not occur, there was a loss of substance in the tibia, and bony healing could not be expected. In the third case, which was one of congenital pseudarthrosis (Case 6), the upper

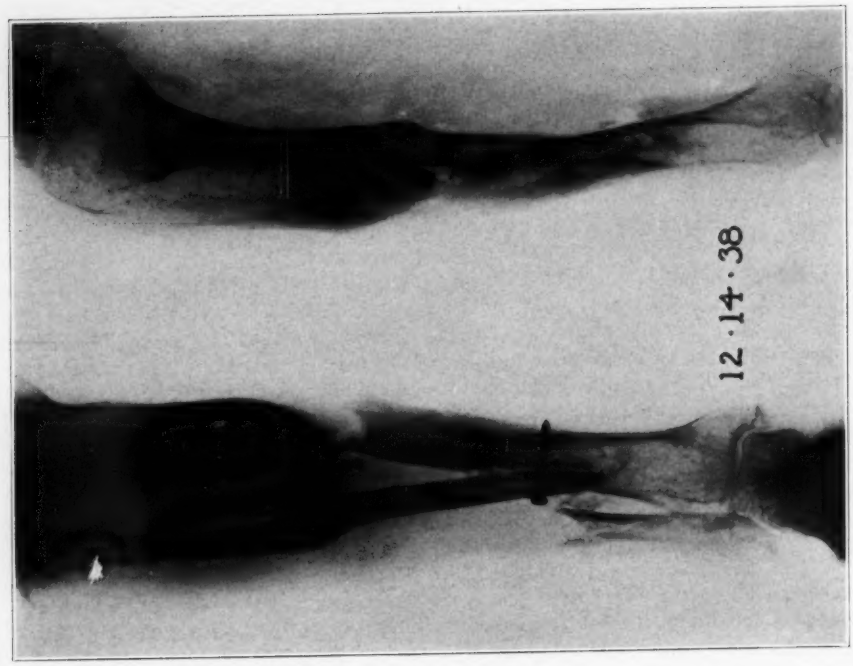

FIG. 10-B
Case 8

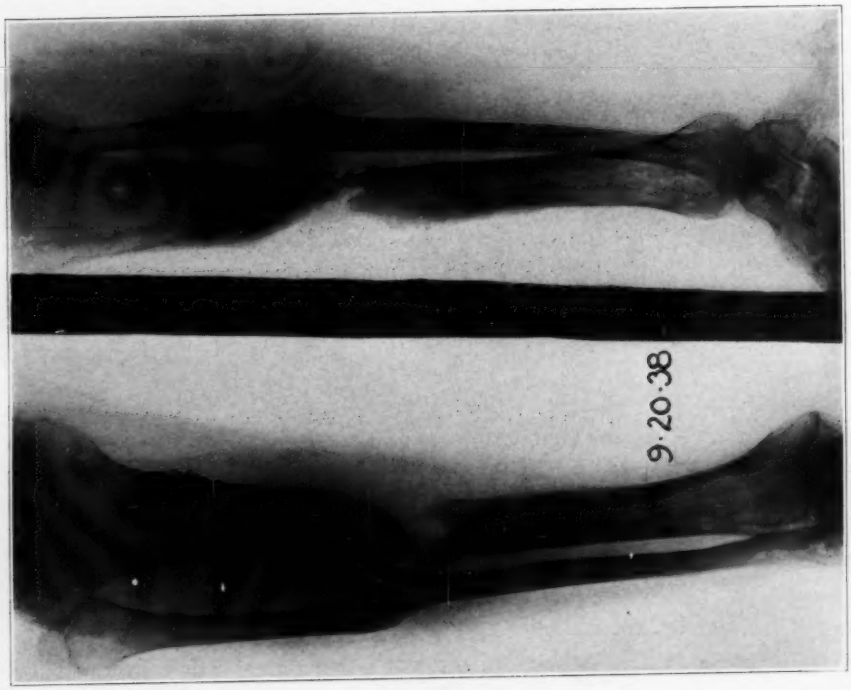

FIG. 10-A
Case 8

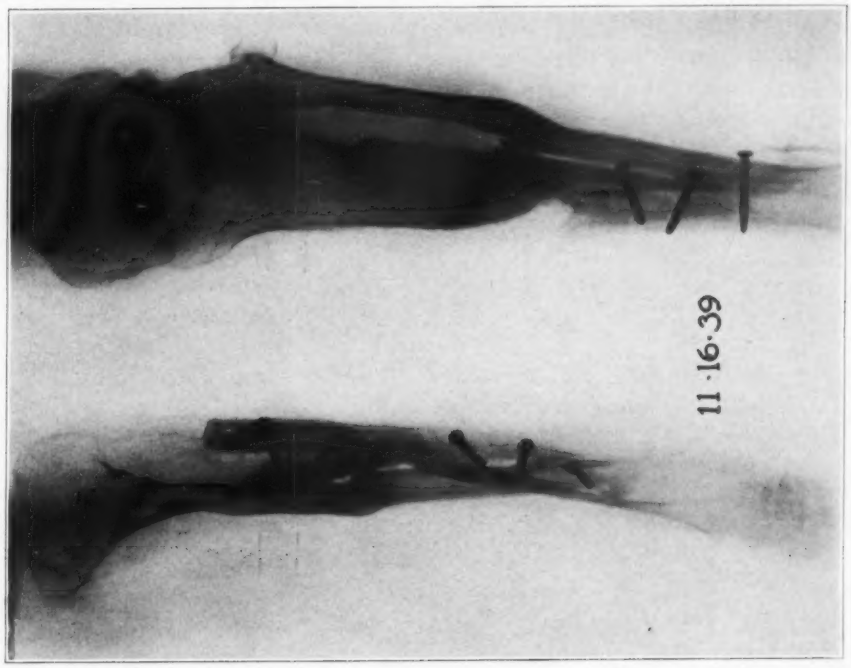

FIG. 10-D
Case 8

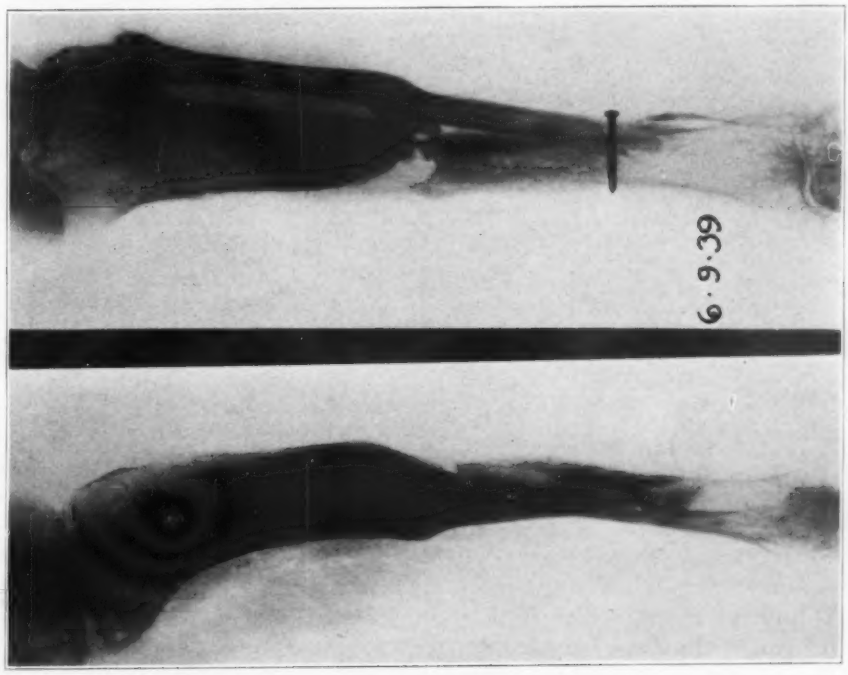

FIG. 10-C
Case 8

fibular fragment was too short to be approximated successfully to the lower tibial fragment, and bone grafts had to be employed to bring about a junction. Union developed promptly, but the roentgenograms leave some doubt as to whether the union of the tibia was secondary to the fibular transplantation or the result of contact with one of the bone grafts.

The author can only attribute this spontaneous healing of the pseudarthrosis to the internal splinting action of the fibular strut. He believes it affords further confirmation of the old principle that bony healing will take place when there is complete and rigid immobilization.

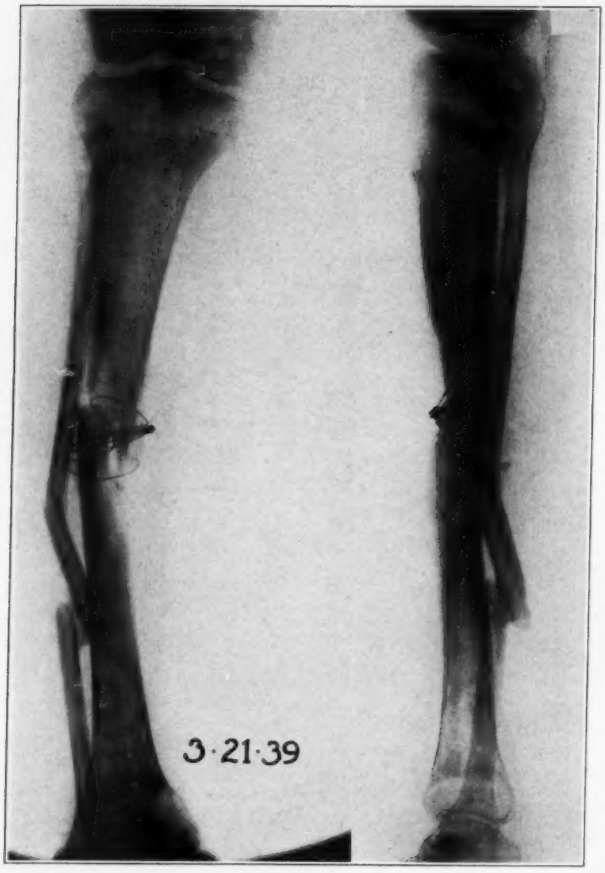

FIG. 11-A
Case 9

The question may be asked why not excise the articular cartilage at the superior tibiofibular joint and obtain the fusion of the upper end of the fibula there, instead of performing the more complicated operation described. In reply, it can be pointed out that in the case of children this could not be done without danger of causing serious distortion of epiphyseal growth. In the adult cases it is doubtful if it would be equally effective in bringing about tibial union, because the fibula being flexible, and the point of junction higher on the tibia than with the method described, there is greater likelihood of movement at the tibial pseudarthrosis. Demonstrable mobility of the tibial fragments was noted in two cases where this method was employed,—one, Case 8 of this series, and the other, the work of another surgeon.

In two of the cases in which fibular transplantation was done, there was bone infection at the point of pseudarthrosis, and draining sinuses, and in one other, although the wound was healed, infection had been

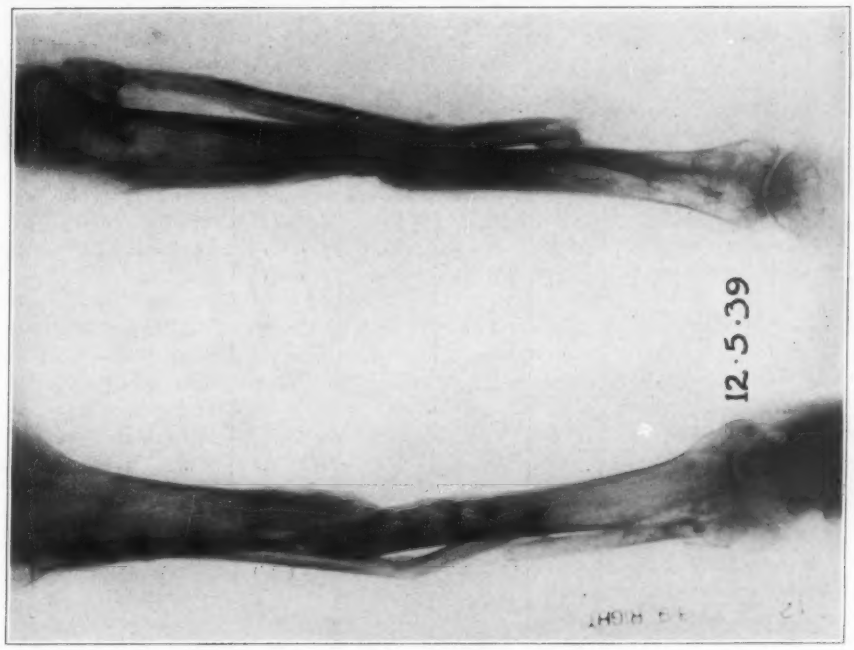

Fig. 11-C
Case 9

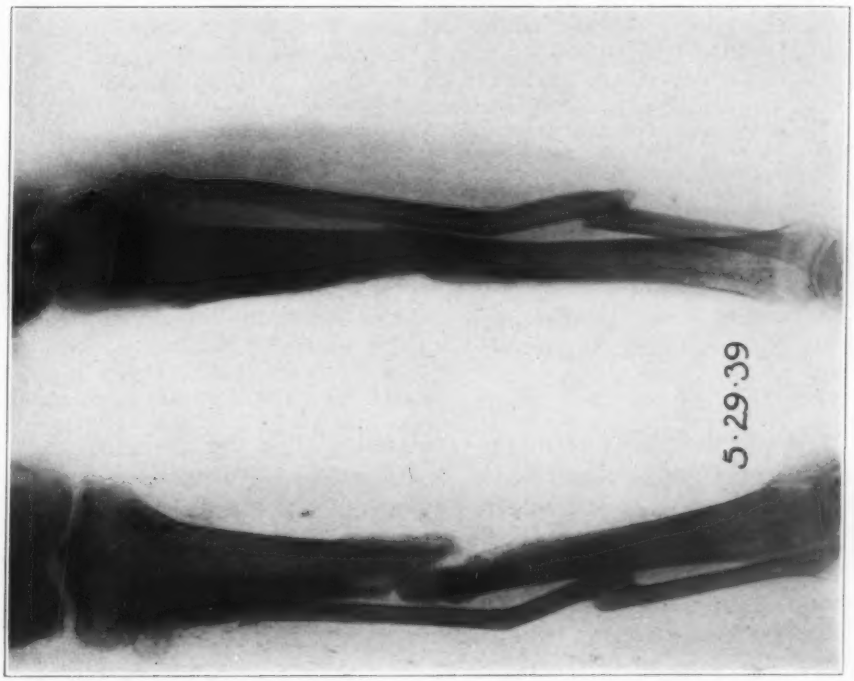

Fig. 11-B
Case 9

TABLE I

SUMMARY OF CASES

Case No.	Name	Age at Operation	Previous Bone Grafts	Infections	Union After Transplantation			Later Bone Grafts	
					Upper End of Fibula	Lower End of Fibula	Pseudarthrosis	Purpose	Result
1	A.N.	35	2	No	Yes	Yes	Yes		
2	M.D.	24	0	Yes	No *	Yes	Yes		
3	D.S.	8	2	No	Yes	Yes	Yes	Reinforcement.	Union
4	E.G.	5	0	No	Yes	Yes	Yes	Reinforcement.	Union
5	P.C.	6	1	No	Yes **	Yes †	No	Non-union of tibia.	Union
6	M.D.	6	1	No	Yes	No	No	Non-union of tibia and reinforcement of tibial-fibular junction.	Union
7	D.R.	6	0	No	Yes	Yes	Yes		
8	F.L.	49	0	Yes	Yes	Yes	No	Non-union of tibia.	Union
9	J.V.	39	0	Yes	Yes	Yes	Yes		

* Union was later obtained after two further operations.

† The lower end of the upper fragment of the fibula was transplanted to the lower fragment of the tibia, and was later followed by a successful bone-grafting operation.

** Transplantation of the upper end of the proximal fragment of the fibula was made necessary by a refracture of the tibia.

present so recently that there would have been danger in attempting a bone-grafting operation. In all of these cases, fibular transplantation afforded the only safe solution of a problem that would otherwise have had to be postponed for many months.

SUMMARY

A simple method of two-stage transplantation of the fibula into the tibia has been used in nine cases of complicated pseudarthrosis. These included four adults of whom three had infected pseudarthrosis, and one uninfected, but with pseudarthrosis still present following two previous bone-grafting operations; and five children with congenital pseudarthrosis or pseudarthrosis resulting from operative correction of congenital bowing, in four of whom previous bone-grafting operations had been done with failure. Bony union of the pseudarthrosis developed spontaneously in six of these nine cases, and in the others supplementary bone-grafting operations resulted in success.

Fibular transplantation has a much wider application in the treatment of tibial pseudarthrosis than has been previously realized, and should not be reserved for those cases in which there are gross tibial defects. The method is worth consideration in cases of infected or complicated pseudarthrosis, and also in the congenital pseudarthrosis of childhood.

REFERENCES

BADGLEY, C. E.: Two Stage Transplantation of Fibula for Tibia. Warthin Anniversary Volume, p. 567. Ann Arbor, 1927.

BARBER, C. G.: Congenital Bowing and Pseudarthrosis of the Lower Leg. Manifestations of von Recklinghausen's Neurofibromatosis. Surg. Gynec. Obstet., LXIX, 618, 1939.

CAMPBELL, W. C.: Transference of the Fibula as an Adjunct to Free Bone Graft in Tibial Deficiency. Report of Three Cases. J. Orthop. Surg., I, 625, Oct. 1919.

CARRELL, W. B.: Transplantation of the Fibula in the Same Leg. Transposition of the Fibula for Loss of the Tibial Diaphysis. J. Bone and Joint Surg., XX, 627, July 1938.

COLONNA, P. C.: Congenital Pseudarthrosis of the Leg. Three Cases Treated by Massive Bone Graft. J. Am. Med. Assn., CIII, 2012, 1934.

CREYSSEL, J., ET COLSON, P.: Modifications des os de la jambe dans un cas d'opération de Hahn-Huntington. Ann. d'Anat. Path., XIII, 545, 1936.

EIKENBARY, C. F.: Transplantation of the Entire Fibula to Replace the Tibia. Northwest Med., XXVII, 284, 1928.

DUCROQUET ET COTTARD: Pseudarthrose congénitale de jambe. Déformation osseuse de la neurofibromatose. J. de Chir., LIII, 483, 1939.

GIRDLESTONE, G. R., AND FOLEY, W. B.: Extensive Loss of Tibial Diaphysis; Tibio-Fibular Grafting. British J. Surg., XX, 467, 1933.

HAHN, EUGEN: Eine Methode, Pseudarthrosen der Tibia mit grossem Knochendefekt zur Heilung zu bingen. Zentralbl. f. Chir., XI, 337, 1884.

HALLOCK, HALFORD: The Use of Multiple Small Bone Transplants in the Treatment of Pseudarthrosis of the Tibia of Congenital Origin or Following Osteotomy for the Correction of Congenital Deformity. J. Bone and Joint Surg., XX, 648, July 1938.

HENDERSON, M. S.: Congenital Pseudarthrosis of the Tibia. J. Bone and Joint Surg., X, 483, Apr. 1928.

HUNTINGTON, T. W.: Case of Bone Transference. Use of a Segment of Fibula to Supply a Defect in the Tibia. Ann. Surg., XLI, 249, 1905.

MANDRUZZATO, F.: La sostituzione peroneale della tibia. Arch. di Ortop., LV, 99, 1939.

MARCONI, SANDRO: Perone pro tibia. Considerazioni su 4 casi operati. Chir. d. Org. di Movimento, XXIV, 552, 1939.

MARIANTISCHIK, L. P.: Über den Ersatz der Tibia bei totaler Resektion der Diaphyse. Zentralbl. f. Chir., LVI, 971, 1929.

MOULONGUET, P.: Transplantation du péroné pour réparer une perte de substance du tibia. Bull. et Mém. Soc. Nat. de Chir., LV, 819, 1929.

MÜLLENDER, ANTON: Zur Frage der Fibulaimplantation bei grossen Tibiadefekten. Zentralbl. f. Chir., LVI, 1924, 1929.

RICH, E. A.: Fibular Transplant. J. Bone and Joint Surg., XI, 398, Apr. 1929.

SATTA, F.: Perone pro tibia (Trapianto di Hahn). Arch. di Ortop., XLV, 762, 1929.

STEWART, W. J.: Osteosynthesis Preceding Extensive Bone-Grafting. J. Bone and Joint Surg., XXII, 403, Apr. 1940.

STONE, J. S.: Partial Loss of the Tibia Replaced by Transfer of the Fibula, with Maintenance of Both Malleoli of the Ankle. Ann. Surg., XLVI, 628, 1907.

SPONTANEOUS FRACTURE OF THE FEMORAL NECK FOLLOWING ROENTGEN-RAY THERAPY OVER THE PELVIS

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From the Pondville Hospital, Massachusetts Department of Public Health, Wrentham, Massachusetts

Spontaneous fracture of the femoral neck, following roentgen-ray therapy directed over the pelvis for the treatment of malignant disease, is fortunately an unusual complication of such treatment. It is sufficiently important, however, to warrant the consideration of those who use roentgen-ray therapy, and should be borne in mind whenever the dosage and the size and position of the portals are being planned for the treatment of malignant disease within or about the pelvis. Because there are relatively few reports in the literature concerning spontaneous fracture of the femoral neck following roentgen-ray therapy, and since there seems to be considerable variation in the incidence of this complication in large series of cases receiving roentgen-ray therapy over the pelvis, the experience regarding this entity is being reported with the hope that, as more data are gathered concerning it, the important factors regarding its cause will become apparent. Measures can then be taken more intelligently to guard against its occurrence in the future.

Although this entity was first reported in 1927 by Baensch [1], only a few case reports appeared in the literature until 1936 when Dalby, Jacox, and Miller reviewed a series of 471 patients who had received roentgen-ray therapy over the pelvis. In this group, there were ten cases of fracture of the femoral neck, an incidence of 2.1 per cent. In May 1939, Peck reported an incidence of 2.8 per cent. in 1026 cases of pelvic malignancy treated by roentgen-ray. These reports are quite interesting, not only because of the pathological material which was available for study, but also because of the high incidence of this complication following roentgen-ray therapy over the pelvis. It is not immediately apparent why the latter should be high in some clinics and low in others, where cases with the same types of pathology are treated with roentgen-ray therapy and are carefully followed afterwards.

A review of the cases of primary malignancy in the region of the pelvis, which were treated by roentgen-ray in this Hospital, revealed a total of 1084 cases between the years of 1927 and 1939. Some of these patients had both roentgen-ray therapy and radium, but others, who received radium alone, are not included in this series. In this entire group, there has been one case of fracture of the femoral neck without evidence of metastatic malignancy to account for the fracture, an incidence of .09 per cent. All other cases of fracture of the femoral neck have had roentgenographic findings characteristic of metastatic disease. In spite of its

rarity it is believed that the following case of fracture of the femoral neck is not due to metastatic disease, but to changes secondary to roentgen-ray therapy,—namely, fibrosis resulting in impaired blood supply and osteoporosis.

An American toolmaker, fifty-eight years of age, was first seen in the Out-Patient Department on September 1, 1937, because of a sore on the penis. He gave a history of having had a circumcision three years previously. Following this, there remained a small area near the fraenum which failed to heal. The patient neglected to have anything done about it until fourteen months before his visit to the Out-Patient Department. The lesion was then removed by his family doctor who told him that it was a cancer. Several months later, a recurrence appeared for which he received a few "electrical treatments". In spite of these, the recurrence rapidly increased in size, and, at the time of his visit to the Out-Patient Department, was causing considerable pain in the penis and perineum.

The past history, marital history, and family history were essentially negative, except that his father died of carcinoma of the throat.

Physical examination showed a well-developed, well-nourished man of fifty-eight with good color. Heart, lungs, and abdomen were essentially negative. A firm node could be felt in the right inguinal region, the nature of which was questionable, because of extensive infection in the ulcerating new growth involving the penis. The glans was almost completely eroded by the tumor, which also extended a short distance along the shaft of the penis. The scrotum was negative to examination.

The patient was admitted to the Hospital at once. After a period during which antiseptic dressings were applied to the ulcerating area on the glans, a radical amputation of the penis was done, and the urethra was transplanted to a perineal opening. Following a satisfactory postoperative convalescence, he was given a series of roentgen-ray treatments consisting of 1600 roentgen units to each groin through portals, ten by fifteen centimeters, over each groin. He received 400 roentgens at each treatment from a 200-kilovolt machine, with .5 millimeters of copper for filtration at a distance of fifty centimeters. He was discharged on October 28, 1937.

The patient was followed in the Out-Patient Department, and, when seen there on February 9, 1938, about four months after his discharge from the Hospital, his only complaint was pain in the left leg, aggravated by weight-bearing. Examination of the operative scars and groins showed no evidence of recurrence, and the perineal urethral opening was functioning well. A roentgenogram of the patient's left hip at that time revealed evidence suggestive of a fracture of the neck of the left femur with slight deformity (Fig. 1). The duration of this fracture, however, could not be determined by the roentgenographic findings. When the patient was next seen in the Out-Patient Department on October 19, 1938, eight months later, he was walking with the aid of two canes, and had a considerable limp. On examination, he was found to have limitation of motion of both hips, more marked on the left, and spasm about the left hip. Again there was no evidence of recurrence in the region of the operative scars or in either groin. Roentgenograms of the pelvis and both hips showed marked arteriosclerosis and generalized osteoporosis. There was further rarefaction of the left femoral head and neck, and no evidence of callus formation at the fracture line (Fig. 2). A fracture had also occurred in the right femoral neck, but there was slight evidence of healing with a coxa varus deformity.

The patient was admitted to the Hospital for the second time on October 23, 1938, for further study. Roentgenograms of the patient's skull, chest, and extremities, with the exception of the right tibia, were essentially negative. In the upper portion of the right tibia a small, elongated cavity was found. This contained irregular areas of calcification, suggesting an old healed osteomyelitis with small sequestra.

Laboratory studies of the patient's blood revealed a slight secondary anaemia. The blood calcium was 10 milligrams per 100 cubic centimeters of blood and the phosphorus, 3 milligrams per 100 cubic centimeters of blood. The blood Wassermann was negative.

FIG. 1

Spontaneous subcapital fracture of the left hip following roentgen-ray irradiation to the pelvis.

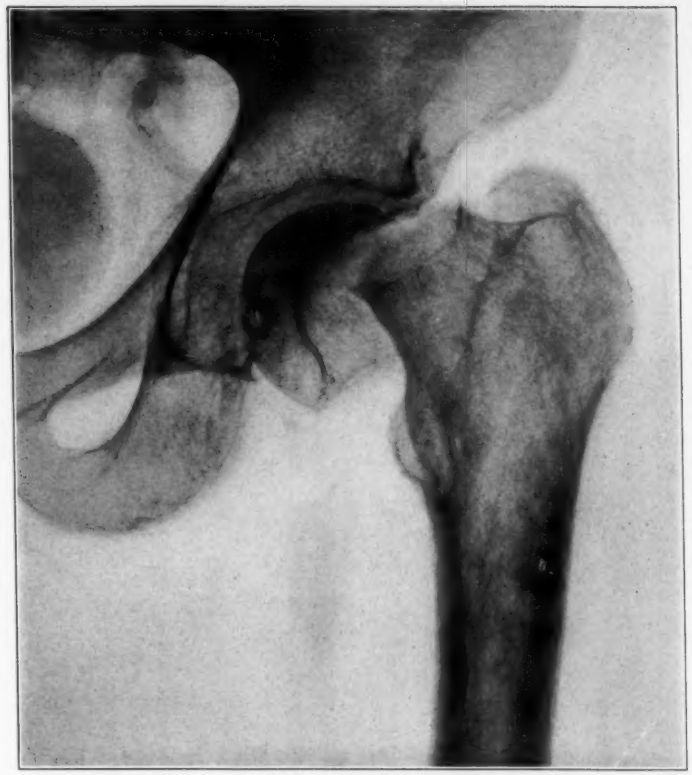

FIG. 2

The same hip eight months later, showing an obvious fracture, radiation osteonecrosis, and rarefaction of the femoral neck and head.

FIG. 3

Taken April 2, 1941, showing no metastasis. Progressive absorption of the head of the femur on the left has left the end of the nail uncovered. Corrective measures are being considered to prevent further erosion of the acetabulum. The old fracture of the right femoral neck, which healed with a coxa varus deformity, can also be noted.

It became apparent, therefore, that the patient had no marked generalized disturbance of calcium and phosphorus metabolism, and that the osteoporosis was chiefly limited to the bones of the pelvis and upper femora.

The patient was seen by an orthopaedic consultant who advised the insertion of a triflanged nail in the left hip, since there was no evidence of healing. This was done at the Massachusetts General Hospital. During his convalescence, repeated blood calcium and phosphorus determinations were again essentially normal. The quantitative twenty-four-hour output of calcium in the urine, while the patient was on a low-calcium diet, was also normal. He was finally discharged from the Hospital on February 19, 1939. At that time, he was able to get about quite well with the slight aid of crutches.

The marked degree of localized osteoporosis can be seen in the photographs which show the hip before the nail was inserted (Figs. 1 and 2).*

The patient has returned periodically to the Out-Patient Department. On November 11, 1939, he was still using crutches some, and walked with a definite limp. His general condition, however, was good and there was no evidence of recurrence either in the groin or in the region of the operative scar. Roentgenograms of both hips showed a persisting slight coxa varus deformity of the right femoral neck. There was no evidence of callus formation about the fracture in the left femoral neck.

He was last seen on April 2, 1941, three and one-half years after his first operation at this Hospital. No evidence of recurrent malignancy was found either in the region of the operative scar or in the groin. Roentgenograms of the patient's pelvis and hips (Fig. 3) show the coxa varus deformity of the right femoral neck. Following the insertion of the Smith-Petersen nail, about twenty-nine months ago, the femoral head was fixed so as to permit weight-bearing on the normal joint surfaces. Since then the upper portion of the femoral head has undergone further absorption, thereby leaving the upper aspect of the

* These photographs were loaned to and used by Batt and Hampton.[3]

inner end of the nail uncovered. As a result of this, the nail impinges on the acetabulum causing erosion of its upper surface as the patient walks. The patient, however, gets around surprisingly well.

There has not yet been opportunity to study microscopically the changes present in the femoral neck which fractured following radiation. However, in view of the changes known to occur in tissues following radiation, it would appear logical that fibrosis and decreased vascularity might also occur in bone following roentgen-ray therapy. Furthermore, when a patient already has marked arteriosclerosis, with changes in the larger vessels which can be visualized by roentgen-ray, it would seem likely that additional damage to the walls of the smaller arteries, such as thickening and hyalinization following radiation, would seriously impair their function, if not actually occlude them. According to Dalby, Jacox, and Miller, who have had pathological material to examine in such cases, these changes do occur. Because the blood supply to the femoral neck is relatively vulnerable, particularly in older people, radiation changes might be expected to result in serious impairment of the nutrition of this structure with such secondary effects as osteoporosis. Fracture of the femoral neck could then be expected without trauma. It is of interest to note that there was no history of trauma in the case just reviewed, or in most of the cases reported by Dalby, Jacox, and Miller.

In view of the incidence of fracture of the femoral neck, 2.1 per cent., as reported by Dalby, Jacox, and Miller in their series of 471 cases, it is surprising that this entity has not been reported more often by other clinics where large numbers of cases are treated. A review of the technique of roentgen-ray treatment at this Hospital reveals that the roentgen-ray portals are seldom large enough or so placed as to include the region of the femoral heads and necks. The cases of pelvic malignancy which are treated with roentgen-ray therapy are usually given treatment through four pelvic portals not larger than ten by ten centimeters, and are placed near the mid-line. Formerly two large portals twenty by twenty centimeters, one anteriorly and one posteriorly, were used. Occasionally a perineal portal not larger than ten by ten centimeters was used. The dosage depends on the location and nature of the malignancy, but seldom exceeds 1800 roentgens per portal during one series of treatments. The use of a 200-kilovolt machine with a filtration of .5 millimeters of copper at a distance of fifty centimeters is the standard technique.

In the case just reviewed, it will be noted that the patient received a total of 1600 roentgens through each of two portals, ten by fifteen centimeters, and, furthermore, that these portals were located over the groins. Inasmuch as there are many other cases in the total group that received roentgen-ray treatment over the groins in equal or larger doses without apparent change in the femoral neck, one is not justified from these data, in assuming that the pathological changes are entirely due to changes secondary to roentgen-ray *per se*. It would seem likely that the extent of vascular damage already caused by arteriosclerosis would be an

important contributing factor. It is conceivable, however, that large doses of roentgen-ray therapy, or repeated doses through portals including the femoral necks, would cause sufficient fibrosis eventually to give the same end result of osteoporosis and fracture. The failure of callus to form is not surprising in view of the marked vascular disturbance. A fibrous union does form, and apparently may become sufficiently strong to permit some degree of weight-bearing.

SUMMARY

1. The case of fracture of the femoral neck here reported is the first at this Hospital in a series of 1084 cases receiving roentgen-ray treatment over the pelvis, an incidence of .09 per cent.

2. The fracture resulted from weight-bearing in the presence of marked osteoporosis, developing in a bone whose blood supply had first been impaired by arteriosclerosis, and was then further damaged by roentgen-ray therapy and fibrosis.

3. At the present time, about three years since the fracture occurred, there has been no callus formation demonstrable by roentgenograms.

4. When roentgen-ray treatment is given over the pelvis, the portals should be placed so that they do not include the region of the femoral necks. If this is unavoidable, the portals should be as small as possible.

REFERENCES

1. Baensch, W.: Knochenschädigung nach Röntgenbestrahlung. Fortschr. a. d. Geb. d. Röntgenstrahlen, XXXVI, 1245, 1927.
2. Baensch, W.: Über Spontanfrakturen des Schenkelhalses nach Röntgenbestrahlung. Röntgen-praxis, IV, 716, 1932.
3. Batt, R. C., and Hampton, A. O.: Spontaneous Subcapital Hip Fractures Occurring in Tabes Dorsalis. J. Bone and Joint Surg., XXII, 137, Jan. 1940.
4. Dalby, R. G.; Jacox, H. W.; and Miller, N. F.: Fracture of the Femoral Neck Following Irradiation. Am. J. Obstet. and Gynec., XXXII, 50, 1936.
5. Kropp, L.: Ueber Spontanfrakturen des Schenkelhalses nach Röntgenbestrahlungen wegen Uteruskarzinoms. Münchener med. Wchnschr., LXXXI, 214, 1934.
6. Okrainetz, C. L., and Biller, S. B.: Fracture of the Neck of the Femur Complicating Roentgen Therapy of Ovarian Cancer. Am. J. Roentgenol., XLII, 883, 1939.
7. Peck, W. F.: Fractures of Femoral Neck Following Pelvic Irradiation. Univ. Hosp. Bull., Ann Arbor, V, 33, 1939.
8. Philipp, Ernst: Knochenerkrankungen bei wegen Uteruskarzinoms mit Röntgenstrahlen bestrahlten Frauen. Strahlentherapie, XLIV, 363, 1932.

SUBCLAVICULAR DISLOCATION OF THE OMOHYOID MUSCLE BY RUPTURE OF ITS BINDING FASCIA

BY H. L. WENGER, M.D., NEW YORK, N. Y.

A thorough search of the literature has failed to show any case of dislocation of the omohyoid muscle by rupture of its binding fascia following an indirect trauma. A report of a case is, therefore, of interest.

H. B., a white male, forty years old, who was a sheet-metal worker, had noted a "lump in his left shoulder" about a week before examination. It was located in the posterior triangle of the neck. About a week earlier, he had been lifting a heavy piece of machinery and felt a snap in the shoulder, followed by immediate severe pain in the left shoulder and in the left side of the neck. During the next two days the pain gradually decreased until he became free of pain. A week after the injury, as he was shaving, he noticed a large lump above his left collar bone. The past history was irrelevant.

Directly above the middle of the left clavicle there was a mass, approximately three inches in diameter (Fig. 1). The function of the left upper extremity was unimpaired. There was no pulsation of the mass nor was there impulse on coughing. Inspiration caused no change in the size of the mass. It was soft and easily reduced. The absence of pulsation, thrill, or bruit eliminated the possibility of a traumatic aneurysm of the subclavian artery. Auscultation ruled out any pulmonary pathology.

It was particularly noticed that when the scapula was depressed by downward pull upon the slightly abducted and flexed arm, the mass disappeared (Fig. 2). The easily palpable edges of the trapezius and sternocleidomastoid muscles were found not to be involved. The only structure that would explain this phenomenon was the omohyoid muscle. A preoperative diagnosis of rupture of the omohyoid muscle and tear of the cervical fascia was made.

The patient was admitted to the New York Post Graduate Hospital on December 28, 1939. Under cyclopropane-oxygen anaesthesia, a curved horizontal incision was made in the base of the neck. This incision was placed about a fingerbreadth above the left clavicle and began at the posterior edge of the sternocleidomastoid muscle, and ran laterally toward the trapezius. The platysma was dissected through bluntly, and the supraclavicular fossa exposed. The supraclavicular nerves were identified and retracted. The patient was then forced by the anaesthetist to inhale strongly, which caused balloon-

FIG. 1

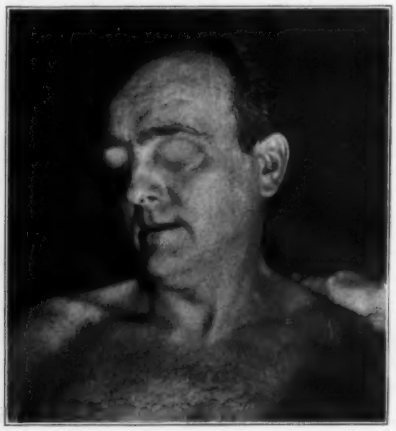

FIG. 2

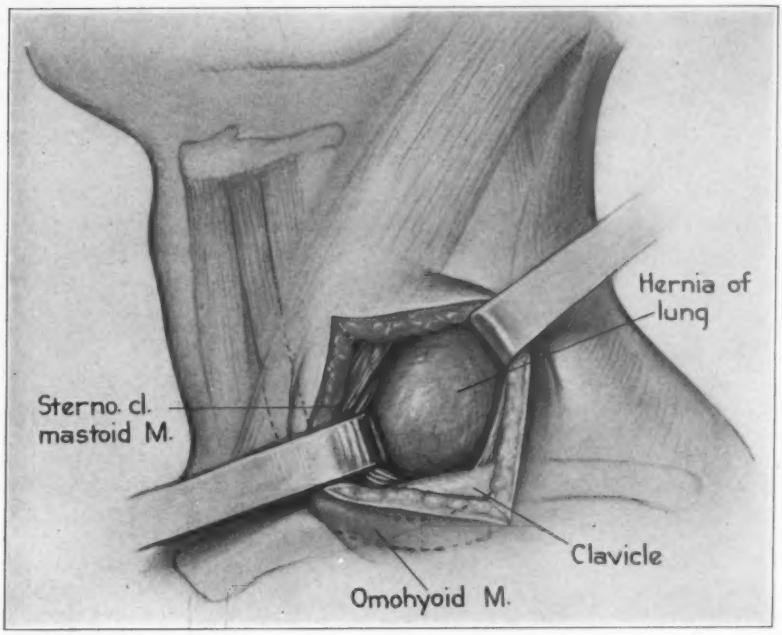

FIG. 3

ing of the apex of the lung which had protruded into the supraclavicular fossa. The omohyoid muscle was found, after long search, behind the clavicle, torn from its binding, deep cervical fascia. Sibson's fascia over the cupola of the lung was also torn (Fig. 3). The central tendinous part of the omohyoid muscle was sutured to the cervical fascia near the apex of the lung, restoring the angle of the omohyoid. The tissues over the apex of the lung were reinforced by suture. The wound was closed in layers and a rubber drain inserted superficially.

The postoperative course was not eventful and the patient was discharged on the second postoperative day with the left arm in a sling.

A biopsy of the adjacent trapezius muscle showed muscle fibers closely packed in bundles. They were in part normally striated, and in part homogeneous and hyaline. Some showed basophilic staining and some necrotic nuclei with fine stippling, with here and there extravasations of blood, indicating traumatized and degenerated muscle.

The immediate end result of this case was satisfactory. The patient has no disability at the present time although he is conscious of a small bulge in the supraclavicular fossa. This is visible to the examiner, but is very much smaller than the original mass. He returned to heavy work about two and one-half months after the operation. The overlying scar in the neck is rather dense and adherent to the underlying structures.

SUMMARY

A hitherto unrecorded subclavicular dislocation of the omohyoid muscle by rupture of its binding fascia, following indirect trauma, is reported. The apex of the lung bulged into the supraclavicular fossa on inspiration because its covering cervical fascia had been torn. In the differential diagnosis, it is absolutely necessary that aneurysm of the subclavian artery be ruled out. It is a tribute to the strength and binding power of the deep cervical fascia, as of all deep fascia, that it is so seldom torn by indirect violence.

GIANT-CELL SYNOVIAL TUMOR OF THE KNEE

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From the Hospital for Joint Diseases, New York

Solitary tumors of the articular structures of joints are comparatively rare and a preoperative diagnosis is seldom made. De Santo and Wilson[1] have recently reviewed 109 cases of tumors of the synovial membrane and found only five of the giant-cell variety. This neoplasm is regarded as benign, but local recurrence may take place and postoperative radiation should be advised.

CASE HISTORY

J. R., American Negro, aged fifty-two, was first seen by the author on March 1, 1939. He stated that he had fallen down a flight of stairs on June 25, 1938, during which fall he had twisted the right knee. It became painful and swollen, and he consulted a physician who treated him with physiotherapy for several months. He continued to work, but in the course of time the knee became continuously more painful and swollen.

Examination nine months after injury showed the patient in good general condition. He walked with a slight limp on the right side and did not completely extend the knee. In the recumbent position the angle of greatest flexion was 90 degrees, and the angle of greatest extension 170 degrees. The knee was distended with fluid and was one inch larger than the left. There was definite localized tenderness over the medial meniscus, and rotation of the leg inward upon the thigh caused severe pain, but external rotation produced no discomfort. A diagnosis of internal derangement was made, and meniscectomy was advised. Roentgenographic examination showed no pathology of any kind, other than the distention of the joint with fluid.

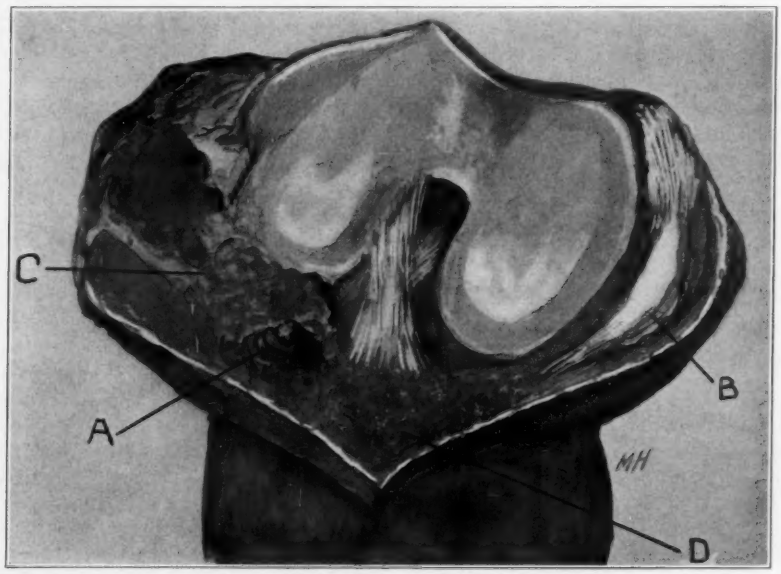

FIG. 1

View of interior of knee joint, showing the tumor.
A: Solitary tumor arising from synovial membrane. *B:* Retracted patella.
C: Hypertrophied synovial membrane. *D:* Enlarged fat pad.

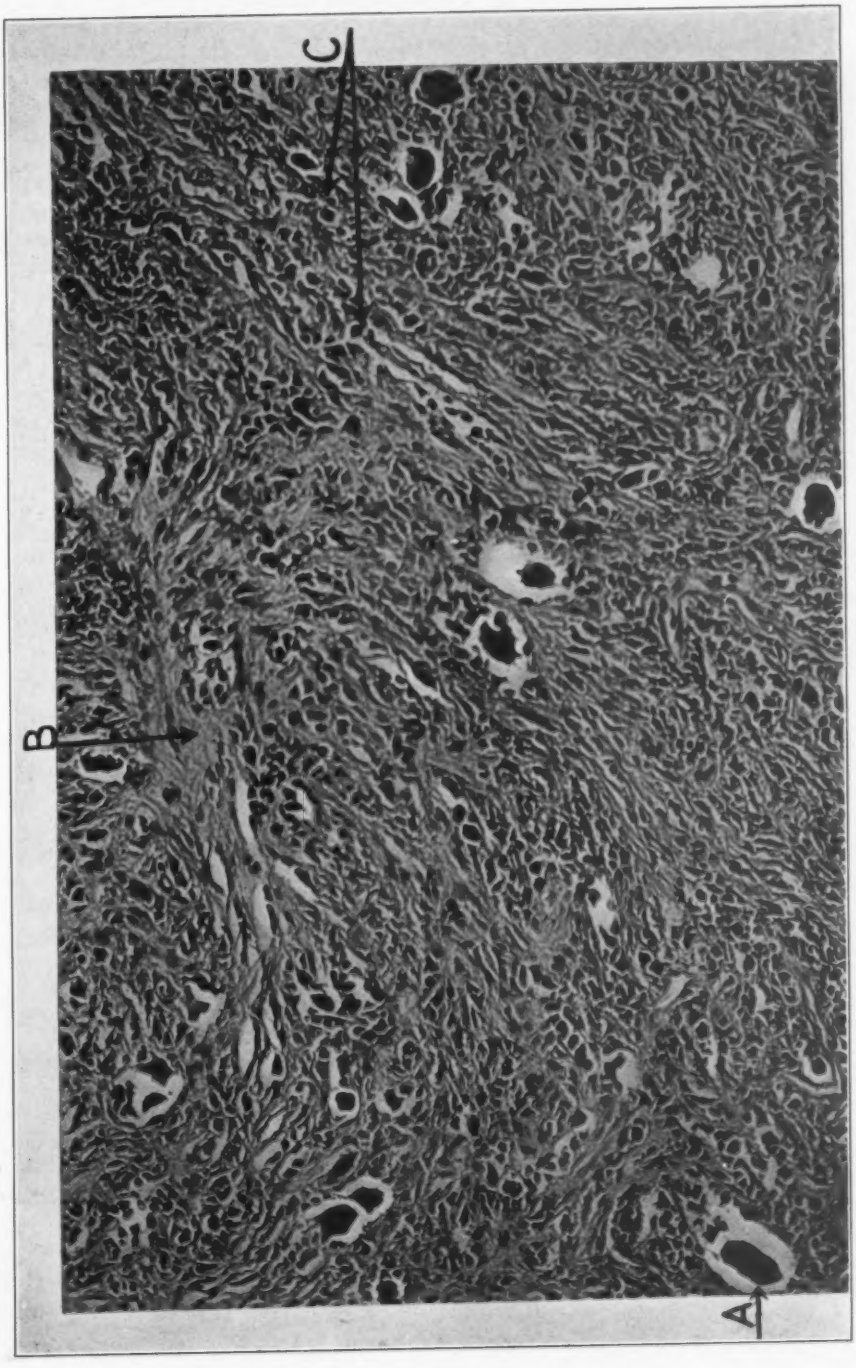

FIG. 2

Photomicrograph of section of tumor tissue. *A*: Giant cell. *B*: Fibrous stroma. *C*: "Synovium-like" cells.

A week after this examination, the distention of his knee was very much greater. The joint was aspirated and about 60 cubic centimeters of dark, oily, amber-colored fluid was removed. The knee was bandaged. The aspiration was repeated about a week later. The joint became distended again and the patient was admitted to the Hospital for Joint Diseases on March 27, 1939. Examination on admission showed the condition to be similar to that previously described, with the addition of distention posteriorly. Diagnosis of a possible Baker's cyst was made.

An arthrotomy was performed April 4, 1939, through a median parapatellar incision. On opening the joint, there was a gush of considerable synovial fluid. The medial meniscus showed a very small tear and was removed. Imbedded in the fat pad, but arising from the synovial membrane reflected over it, there was a yellowish tumor resembling a xanthoma. This was completely excised, the wound closed in the usual manner, and a compression bandage applied. The patient made an uneventful recovery and on April 19, 1939, was discharged, walking with the aid of crutches. He was treated postoperatively with physiotherapy, and on June 9, 1939, was able to return to work. Examination on that day showed that the right knee was moderately swollen. There was no fluid in the popliteal region, and motion of the knee was possible from 180 degrees of extension to 75 degrees of flexion. Measurements showed that the right knee was only half an inch larger than the left.

The pathological report of tissue removed, made by Henry L. Jaffe, M.D., was:

"*Gross Examination:* The specimen consisted of a lesion removed from the region of the ligamentum mucosum. Beneath the synovial lining, there was a rather firm, brownishly discolored, lobulated tumorous growth which measured roughly 2.5 by 2 by 1.5 centimeters. The material received also included a fragment of somewhat injected synovial membrane. Within the latter, a small whitish (in places yellowish) and discolored, discrete nodule, one centimeter in greatest diameter, was encountered. A meniscus was also received which showed nothing remarkable.

"*Microscopic Examination:* Sections showed well-circumscribed tumor nodules with nearby bits of synovial membrane and pieces from other points in the joint. The tumor nodules occupied the entire thickness of the synovial and subsynovial membrane. The tissue consisted of a fibrous stroma containing myriad 'synovium-like' cells and many giant cells. There was no evidence of lipoid-containing foam cells in the routine or spinal fat-stain sections. A small amount of hemosiderin was present. The neighboring synovial and subsynovial membrane was sharply demarcated from the tumor nodules, but showed some villous formation, hyperplasia, and hypertrophy of the synovial cells. There were several focal collections of lymphocytes. The whitish nodule was composed of highly collagenous fibrous tissue which had apparently undergone traumatic damage.

"*Diagnosis:* Giant-cell tumor of the synovial membrane of the knee joint."

Although this patient has been working since June 9, 1939, there has been a recurrence of pain and swelling of the right knee. To relieve this, physiotherapy was instituted and carried out for a number of months without much improvement.

Examination made in October 1939, revealed that the right knee was slightly swollen and contained a small quantity of fluid. Extension was restricted to about 175 degrees, and flexion to 90. The patient walked with a limp on the right side. Motion of the limb was accompanied by pain. He was referred to Dr. James Ewing who instituted deep roentgen-ray therapy. A full course of treatments consisting of 200 roentgen units to the front and 200 roentgen units to the back of the knee was given five times, the last one on January 3, 1940.

Following this treatment, the patient returned to work and when last examined, in August 1940, gave no evidence of recurrence of the tumor, although the knee showed limitation of about 10 degrees in extension and of about 15 degrees in flexion.

At the present time (October 1940), this patient is carrying on his usual occupation of elevator operator and porter.

1. De Santo, D. A., and Wilson, P. D. Xanthomatous Tumors of Joints. J. Bone and Joint Surg., XXI, 531, July 1939.

TUBERCULOSIS OF THE SHOULDER

A Report of Four Cases Treated by Operative Fusion

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Tuberculosis of the shoulder must be differentiated from chronic disabilities of the shoulder which are chiefly the degenerative, traumatic, and infectious arthritides, and the cases of long-standing periarticular calcification and bursitis.

The prognosis after treatment is generally good in uncomplicated cases, but poor when active pulmonary disease or local abscess is present.

The primary treatment is that of general supportive measures. Local treatment may be conservative or operative. Conservative treatment has for its aim the healing of the shoulder joint in an optimum position for function through the various methods of extrinsic splinting only. By this method fibrous ankylosis may occur in three to five years, but it is generally insecure, and the arm from its own weight gradually loses its desirable abducted position, and ultimately comes to rest in a poor functional position.

In the operative field, the procedure of choice in the uncomplicated cases is extra-articular fusion by means of an osteoperiosteal graft from the acromion to the neck of the humerus. Provided that postoperative splinting is proper and of sufficient duration, intra-articular healing and bony ankylosis almost inevitably occur. The arm should be slightly forward and abducted to 70 degrees. Solid fusion has generally taken place in four to eight months. The outcome following intra-articular fusion is unpredictable.

Briefly, the operative technique is as follows: The preoperative orthopaedic preparation is applied to the shoulder and to the opposite leg. Operation is done on the Hawley table. One or two osteoperiosteal grafts (depending upon the size of the patient), measuring one-half by three inches in size, are removed from the tibia and set aside in saline packs. The leg wound is closed. An anterior deltoid-splitting incision, extending over the acromion process, is made, the fibroperiosteum of the acromion and upper humerus is incised and stripped aside, the smooth cortical surface of the acromion and upper humerus is denuded with an osteotome, and the osseous surfaces of the graft are applied to this raw bed of bone. The joint is not entered. Fibroperiosteum is sutured over the grafts with chromic catgut and this holds them securely in place, for during the process the arm has been held in the desired position. The soft tissues are closed in the usual fashion, and the skin

FIG. 1-A

Case 1. Roentgenogram taken September 16, 1936, shows irregularity of the head of the humerus with multiple areas of rarefaction in the greater tuberosity and in the glenoid cavity.

FIG. 1-B

Case 1. Six months after extra-articular fusion, roentgenogram shows solid bony union between humerus and acromion.

is sutured with silk. A plaster shoulder spica is applied with the arm in about 70 degrees' abduction, slightly forward and in neutral rotation.

REPORT OF CASES

Case 1. E. K., a white female, aged forty-eight, was first admitted to the hospital on September 16, 1936, with a history of vague, intermittent pain in the right shoulder joint for twenty-five years. There was occasional radiation to the finger tips. The pain suddenly became worse five months before admission, and marked limitation of motion had occurred. There was no history of trauma or tuberculosis contacts.

There was moderate generalized atrophy of the right shoulder joint and the arm was fixed in adduction. All attempted motions were painful. No inflammatory signs were present. Roentgenograms showed an irregularity of the head of the humerus and multiple areas of rarefaction in the humerus and the glenoid (Fig. 1-A). Laboratory studies were normal.

Exploration was carried out and the joint was found to be filled with soft, friable, whitish-gray granulation tissue. This same material had replaced part of the humeral head. Articular cartilage and necrotic bone of humerus and glenoid were removed and a plaster abduction spica was applied. Microscopic examination of the removed tissue revealed tuberculosis.

After six months of spica fixation, no fusion had occurred. On February 23, 1937, an extra-articular fusion with a tibial osteoperiosteal graft was done by Dr. Maxwell Harbin. An abduction spica was worn for six months when solid bony ankylosis had occurred (Fig. 1-B).

Since then she has had a stable painless shoulder and has had no restriction in the use of the arm (Fig. 1-C).

FIG. 1-C

Case 1. Double-exposure photograph shows range of abduction of right humerus, one year following extra-articular operation.

Case 2. R. S., a white male, eleven years of age, entered the hospital on April 8, 1936, with the complaint of pain in the right shoulder of one month's duration. There was no history of trauma or other joint disease. His father had died from pulmonary tuberculosis.

There was moderate generalized atrophy of the right shoulder joint with fixed adduction to the chest wall. No passive motion was permitted. There was no local heat or tenderness present. Roentgenograms showed extensive destruction of the upper humerus, the capital epiphysis, and the glenoid (Fig. 2-A). A tuberculin test (1:1000 human) was strongly positive. The laboratory findings were normal.

Because of his age, conservative treatment in an abduction spica was carried out for six months, but fusion did not occur, and the abduction gradually decreased during the next five months. On March 6, 1937, an extra-articular fusion with a tibial osteoperiosteal graft was done by Dr. Maxwell Harbin, and an abduction spica was applied.

Microscopic examination of the removed granulation tissue revealed scar tissue, the seat of chronic inflammation, with no evidence of tuberculosis. Solid bony union

FIG. 2-A

Case 2. Roentgenogram taken April 8, 1936, shows marked destruction of the capital epiphysis and of the glenoid cavity. There is a large cystic area in the proximal diaphysis of the humerus.

FIG. 2-B

Case 2. Postoperative roentgenogram shows complete intra-articular and extra-articular bony union four and one-half months after operation.

occurred in four months (Fig. 2-B). He has a painless stable shoulder with no limitation of use (Fig. 2-C).

Case 3. G. P., a white male, eleven years of age, was admitted to the hospital in November 1936, for an arthrodesis of a tuberculous left hip. For two weeks prior to admission he had complained of pain in the right shoulder without any history of trauma.

Slight atrophy of the right shoulder joint was present, and abduction beyond 45 degrees was painful. Roentgenograms revealed an extensive destructive process involving the head of the humerus and the glenoid (Fig. 3-B). Laboratory findings were normal.

During his convalescence from the hip arthrodesis, the shoulder was treated conservatively. On July 22, 1937, Dr. Maxwell Harbin performed an extra-articular fusion of the shoulder joint with a tibial osteoperiosteal graft. Microscopic examination of the granulation tissue revealed tuberculosis. Solid bony ankylosis occurred after four months of abduction splinting (Fig. 3-C).

At present, the right shoulder and left hip are painless and stable, and the patient enjoys normal activities (Fig. 3-A).

Case 4. R. N., a white male, eight years of age, was admitted to the hospital in November 1936, because of a painful right shoulder of ten months' duration. From September 1931 to October 1934 he was treated in another city for dorsal Pott's disease. He made an excellent recovery from a spine fusion and was well until pain in the shoulder occurred.

There was marked diffuse atrophy and muscle spasm of the right shoulder joint. All motion was painful. There was tenderness to pressure over the anterior joint space. He had marked lower dorsal kyphosis. Roentgenograms, taken on admission

FIG. 2-C

Case 2. Double-exposure photograph taken six months after operation shows excellent range of abduction.

FIG. 3-A

Case 3. Double-exposure photograph, taken six months after operation, shows excellent range of abduction.

and others taken nine months later, revealed an extensive destruction of the humeral head and the glenoid (Fig. 4-A). Sedimentation rate was accelerated.

For one year he was treated conservatively in plaster abduction spicas, but fusion did

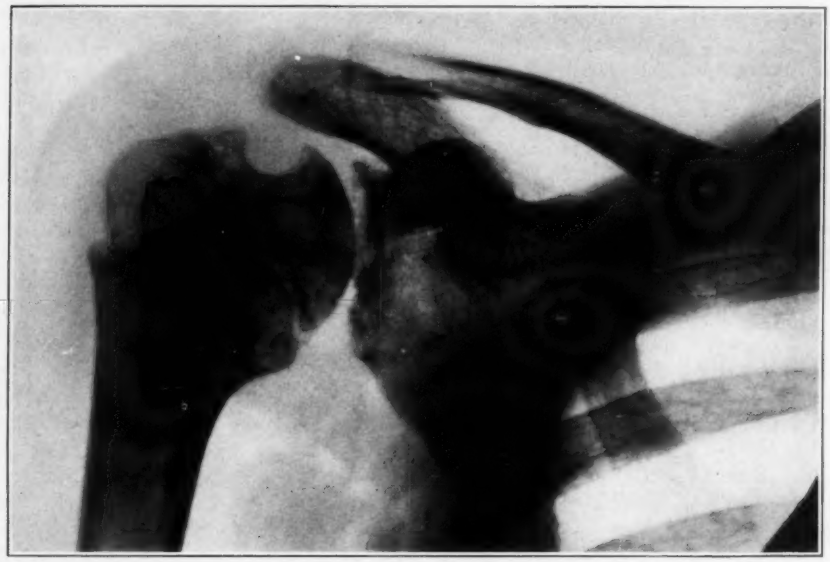

FIG. 3-B

Case 3. Preoperative roentgenogram of the right shoulder taken November 27, 1936, shows marked destruction of the head of the humerus and the glenoid cavity.

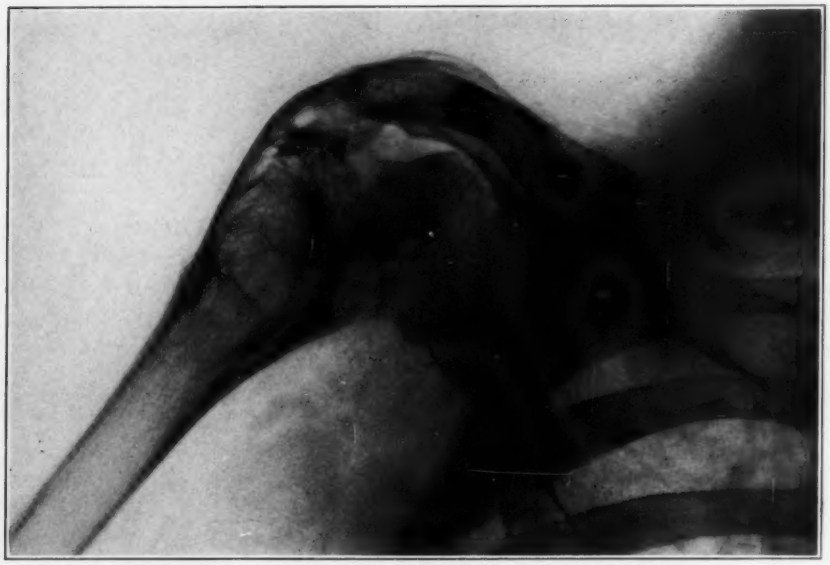

FIG. 3-C

Case 3. Roentgenogram, taken December 14, 1937, four and three-quarters months after extra-articular fusion, shows good bony union.

FIG. 4-A

Case 4. Preoperative roentgenogram of the right shoulder, taken August 21, 1937, after nine months of conservative treatment, shows an extensive destruction of the epiphysis of the humerus and of the glenoid cavity.

FIG. 4-B

Case 4. Roentgenogram, taken April 16, 1938, five months after operation, shows solid bony fusion between the humerus and scapula.

FIG. 4-C

Case 4. Double-exposure photograph taken six months after operation shows range of abduction.

not occur. An extra-articular fusion with a tibial osteoperiosteal graft was done on November 13, 1937, and bony ankylosis was complete in five months (Fig. 4-B). Microscopic examination of the removed granulation tissue had confirmed the diagnosis of tuberculosis. He has a painless stable shoulder with excellent range of motion (Fig. 4-C).

SUMMARY

Four cases of tuberculosis of the shoulder which were treated by extra-articular arthrodesis are presented. Three cases occurred in male children, and the fourth in an adult female. All involved the right shoulder joint. No history of local trauma was elicited in any case. The shortest duration of symptoms before diagnosis was made was two weeks and the longest duration was twenty-five years. Extra-articular fusion was done on these four patients, and bony ankylosis was demonstrated clinically and roentgenologically four to six months after operation. Ankylosis occurred in six months in the adult female, in whom a previous intra-articular fusion had met with failure. The juvenile patients showed solid ankylosis in four to five months after operation, whereas conservative treatment for periods of six, eight, and twelve months, respectively, had failed to produce fusion.

The authors believe that extra-articular arthrodesis of the tubercu-

lous shoulder joint should be carried out as soon as the diagnosis is established, provided that none of the more serious local or systemic complications are present. Intra-articular arthrodesis is unreliable, as evidenced by the failure of fusion in our adult patient, and conservative treatment furnishes no guarantee of healing, unless perhaps fixation be carried out for an interminable period. The shoulder joints of the four patients are healed and are functionally excellent.

BIBLIOGRAPHY

AHERN, E. D.: Surgical Treatment of Tuberculous Disease of the Shoulder Joint. Med. J. Australia, I, 515, 1923.

ALBEE, F. H.: Arthrodesis of the Shoulder. Surg. Clin. North America, V, 439, 1925.

BRAILSFORD, J. F.: The Radiology of Bones and Joints. Baltimore, Wm. Wood, 1934.

CAMPBELL, W. C.: Operative Orthopedics. St. Louis, C. V. Mosby Co., 1939.

CURTIS, F. E., AND BRANCH, H. E.: Extra-Articular Arthrodesis of the Shoulder. J. Bone and Joint Surg., XIX, 511, Apr., 1937.

FARRELL, B. P., AND GEORGE, E. M.: The Decline in Incidence of Tuberculosis of Bones and Joints. Am. J. Surg., XLIV, 380, 1939.

STEINDLER, A.: The Treatment of Tuberculosis of the Upper Extremity. Southwestern Med., XXII, 168, 1938.

WATSON-JONES, R.: Extra-Articular Arthrodesis of the Shoulder. J. Bone and Joint Surg., XV, 862, Oct. 1933.

IRREDUCIBLE LATERAL DISLOCATION OF THE PATELLA WITH ROTATION

A Case Report

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Robert Liston is credited with the remark that, "he never had the fortune to perform the good office of reducing a patella for a patient". The inference, of course, is that the dislocated patella usually reduces itself before the arrival of the surgeon. While most dislocations of the patella are readily reduced, there have been reported, from time to time, cases of luxated patellae which have defied all attempts at closed reduction. Usually these dislocations have been complicated by fractures, luxations of the tibia, or rotary displacements of the patella. The case reported in this communication is of interest in that the lateral dislocation was associated with a complete rotation of the patella about its longitudinal axis.

CASE REPORT

T.P., an electrician, aged forty-three, was brought to the Emergency Hospital in the afternoon of February 3, 1940. He had parked his automobile in the driveway about ten feet from the garage doors. The driveway sloped rather steeply downward into the garage. After setting the hand brake and alighting from the car, he proceeded to unlock the garage doors. The brakes loosened and the automobile rolled down upon him. He attempted to avoid being crushed between the oncoming car and the door by jumping in the air and grasping the radiator cap with his hands. His left knee was caught between the fender of the car and the closed door. The impact was sufficient to tear the door from its hinges and carried him, still clinging to the radiator cap, into the interior of the garage.

FIG. 1

Appearance of left knee prior to reduction.

Examination of the patient on arrival at the Emergency Hospital disclosed slight swelling of the left knee. There were abrasions over both the inner and outer aspects of the knee. The patella could be easily palpated, lying in the sagittal plane over the outer edge of the lateral femoral condyle, and the diagnosis of a lateral dislocation of the patella was obvious (Fig. 1). Roentgenograms were secured which substantiated the clinical findings and in addition revealed an insignificant fracture of the lateral femoral condyle.

An attempt was made to reduce the patella without anaesthesia. Pressure was exerted with both thumbs on its posterior edge, but the patella remained immovable. Ether anaesthesia was administered and after complete relaxation, reduction was again attempted. In spite of full flexion of the hip and extension of the knee, every trial proved ineffectual. Finally after preparation of the skin, a bone hook was inserted around the posterior edge of the patella, to which forceful traction was applied, in an endeavor to slide the patella over the prominence of the lateral femoral condyle. This procedure, like the previous ones, ended in failure.

The following day the patient was returned to the operating room, given a spinal anaesthetic, and again attempts were made to slide the patella back over the lateral femoral condyle. The knee was flexed forcibly about twenty degrees to loosen the locked patella. The hip was sharply flexed on the abdomen to relax the quadriceps, and the knee was fully extended. These attempts again failed to achieve reduction.

Suspecting that rotation of the patella was the cause of our inability to secure reduction, a series of tangential roentgenograms were taken. In one of these views, a true lateral projection of the patella was obtained, which revealed the correct status. The articular surface was found to be directed outward and the non-articular surface faced the femoral condyle. The patella had rotated during its lateral displacement somewhat more than ninety degrees (Figs. 2-A and 2-B).

The skin lacerations about the knee prevented immediate open reduction of the patella. Two weeks elapsed before the skin was sufficiently healed to permit surgical intervention and at the expiration of this time, under general anaesthesia, the knee was opened through a medial parapatellar incision. The distal portion of the quadriceps tendon and the proximal portion of the patellar tendon were exposed, and the early fibroblastic scar tissue was dissected away. The medial attachments of the patella were completely torn; and the patella was avulsed subperiosteally from the vastus medialis, the medial two-thirds of the quadriceps, and the medial half of the patellar tendon. All lateral attachments were intact and the patella had rotated internally about these attachments through approximately 110 degrees, so that its articular surface faced outward (Fig. 3).

FIG. 2-A

FIG. 2-B

Oblique roentgenograms of the left knee (reversed in reproductions). Note the position of the patella lying lateral to the femoral condyle, with the articular surface facing outward. The small fracture of the lateral femoral condyle is visible in Fig. 2-A.

The patella was readily reduced by retracting its anterior edge laterally and inserting a periosteal elevator between the lateral femoral condyle and the patella. Using a periosteal elevator as a skid, the posterior edge of the patella was slipped upward and over the condyle; the patella was derotated spontaneously and fell into position with its articular surface in contact with the patellar surface of the femur.

The surgical repair of the torn structures consisted of suturing the rent between the vastus medialis and quadriceps tendon. The distal fibers of the vastus medialis were affixed to the medial side of the patella with two mattress sutures of braided silk passed through holes drilled obliquely into the edge of the patella. The fascial expansion over the patella, the subcutaneous tissue, and skin were closed in layers with interrupted, black silk sutures. The knee was immobilized in a plaster cast with the knee in approximately fifteen degrees of flexion.

FIG. 3

Photograph of the surgical exposure of the knee. Note the patella lying at the side of the lateral femoral condyle, with its non-articular surface in contact with the femur. The torn medial fibers of the patellar ligament and the quadriceps tendon are apparent.

The wound healed rapidly and the cast was removed on the twelfth postoperative day. Passive motion and quadriceps setting exercises were started. The patient was discharged on the seventeenth postoperative day, using crutches and refraining from weight-bearing upon the left leg. At the time of discharge, there was active extension of the knee to 165 degrees and flexion to 135 degrees. There was no pain or crepitus on motion and no tendency for the patella to luxate laterally.

Soon after discharge from the hospital, the patient, on his own volition, discarded his crutches. One month later, patient had a range of active motion through 50 degrees, with a 15-degree flexion contracture.

Eight months after the open reduction, the patient had no pain, no swelling, and no tenderness. The patella was only slightly movable from side to side. Extension of the left knee was possible to 175 degrees and flexion to 65 degrees. There was no obvious atrophy of the thigh or leg and no demonstrable muscle weakness (Fig. 4).

DISCUSSION

A search through the literature has uncovered few similar cases of lateral dislocation of the patella complicated by rotation about its longitudinal axis. Cooper appears to have recorded the earliest case in 1844. From his description it is difficult to be certain to what extent the patella had rotated during its lateral displacement, but it was sufficient to permit

the patella to come to rest "with its inner edge upon the outer surface of the external condyle, the fore part of the patella facing forwards and inwards. As the patient lay with the knee extended he experienced no pain; there was no tension of the quadriceps extensor cruris; the patella admitted of a slight degree of motion forward or backward, turning upon its inner edge, which seemed caught behind the prominent margin of the articular surface of the condyle." All attempts at reduction were unavailing, until with considerable force the knee was sharply flexed to a point where the heel contacted the thigh. At the termination of this manoeuvre, the patella spontaneously reduced itself.

In 1856, Sanborn reported a similar case in a twenty-year-old man, in which all manipulation was ineffectual until the patient was anaesthetized and the leg was flexed forcibly on the thigh. By this process the patella was lifted from its unnatural position and the reduction was instantaneous. It was not until 1901 that Borchard reported another case of rotary and lateral dislocation of the patella. The injury occurred in a seventeen-year-old boy, who stumbled and fell while in the act of throwing a snowball. Examination of the knee eight hours after the accident disclosed the patella firmly lodged over the lateral femoral condyle. Both the ligamentum patellae and the tendon of the quadriceps femoris could be palpated, but were lax rather than taut. Reduction was accomplished with great difficulty, under anaesthesia, by derotating the patella with the thumb and forefinger. The laxness of the patellar tendon and the tendon of the quadriceps femoris, the author felt, indicated it was the rotation of the patella which locked it over the femoral condyle rather than any tight ligamentous structures. The following year

FIG. 4-A

FIG. 4-B

Appearance of left knee eight months following open reduction. The photographs indicate the range and limits of active motion.

Hotchkiss reported a similar case in a twenty-year-old rigger whose leg became entangled in a rope down which he was sliding. The greatest difficulty, even under deep anaesthesia, was encountered in accomplishing a reduction. The method finally proving successful consisted of sudden forceful overextension of the knee, together with pressure exerted by both thumbs below the edge of the patella, forcing its posterior border over the femoral condyle.

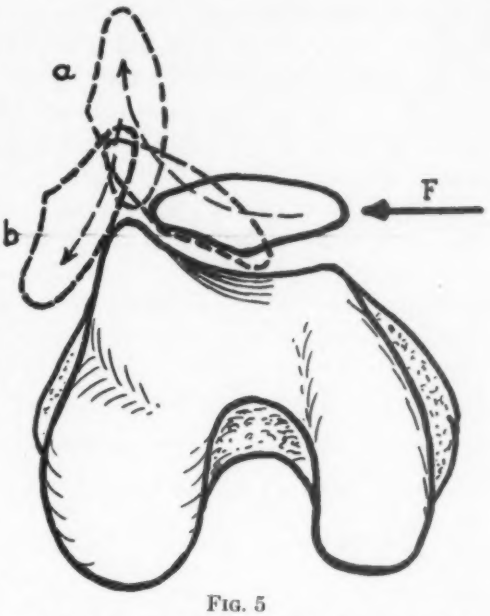

FIG. 5

Sketch showing the path the patella must take in its lateral dislocation with rotation about the long axis. *F:* The direction of the dislocating force; *a:* the position of the patella resulting from its sliding up on the lateral condyle; *b:* the position of the patella, where it becomes locked, after the medial edge clears the condyle.

During the past two decades there have been three additional cases reported by Trausner, Orsós, and Martin. In the case recorded by Trausner, there was a concomitant lateral luxation of the tibia which carried the patella with it. In all these cases, with the exception of the one reported by Orsós, reduction of the patella required surgical intervention; all closed methods proved of no avail. In each case it was found that the patella had rotated so that its medial edge became locked over the border of the lateral femoral condyle, with the articular surface facing outward. After arthrotomy, the dislocations were readily reduced by simply elevating the edge of the patella over the femoral condyle, following which the patella tended to derotate spontaneously and reduce itself. Surprisingly, Martin states that there was no appreciable tearing of the capsular structures demonstrable at operation, in spite of the marked displacement of the patella. This is at variance with the operative findings in the authors' case.

From a review of the cases reported in the literature, and from a study of the authors' own case, it is apparent that such lateral dislocation of the patella, with a rotation about its longitudinal axis, must result from a blow directly upon the medial side of the patella while the quadriceps femoris is taut. It appears to be essential that the knee be in almost complete extension at the time the forces act. This fact suggests the explanation for the rotation of the patella. During the final 20 to 25 degrees of extension of the knee, the patella rides against the lateral femoral condyle, which is bulwarked to resist the normal tendency of the patella to slide laterally. When the dislocating force carries the patella laterally, its

outer edge must ride upon the raised lateral femoral condyle. This produces a torque, tending to rotate the patella about a longitudinal axis. If the primary force is sufficiently great and acts through an adequate period of time, the patella is not only rotated, but carried beyond the lateral femoral condyle over which the medial edge of the patella becomes locked (Fig. 5).

It would seem that a dislocation of this nature would be impossible unless the attachments of the vastus medialis to the patella were avulsed at the same time. Although manual reduction is perhaps possible, once the nature of the rotation has been detected, the authors feel that open reduction is probably the method of choice in order to repair these important attachments, and so restore the full strength of the limb, and prevent any further tendency to lateral dislocation.

REFERENCES

Borchard: Luxation und Torsion der Patella nach aussen durch Muskelzug. Deutsche Ztschr. f. Chir., LX, 577, 1901.

Brown, F. T.: Rotation and Outward Dislocation of the Patella. Ann. Surg., XXXV, 636, 1902.

Cooper, Astley: A Treatise on Dislocations and Fractures of the Joints. p. 178. Philadelphia, Lea and Blanchard, 1844.

Martin, B.: Fest eingeklemmte seitliche Luxation der Patella. Zentralbl. f. Chir., LVII, 131, 1930.

Orsós, Eugen: Mit äusserer Torsion komplizierte Kniescheibenverrenkung nach aussen. Zentralbl. f. Chir., LIII, 1506, 1926.

Sanborn, E. K.: Lateral Luxation of the Patella, of difficult Reduction. Boston Med. and Surg. J., LIV, 175, 1856.

Trausner, Hanns: Ein Fall von Luxatio Genu mit Einwärtsrotation der Patella um 180 Grad. Med. Klin., XIX, 832, 1923.

TESTICULAR TERATOMA METASTASIZING TO THE SPINE

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It is generally believed that more than 96 per cent. of testicular tumors are malignant.[1]

Metastasis occurs by way of the lymphatic and venous systems. When by the lymphatic route, extension is up the lymphatics of the spermatic cord to the pelvic, lumbar, and epigastric nodes, thence to the prevertebral chain, through the mediastinum and along the thoracic duct to the left supraclavicular fossa. When by the venous system, metastasis is first pulmonary in nature. By either route the metastasis is rapid.[1]

A laboratory aid in diagnosis and prognosis is to be found in the determination of the presence of prolan A in the urine. This test has now been refined and is used not alone in the diagnosis, but as a guide to the progress of the patient, and the response of the tumor to radiation. The persistence of a strongly positive prolan test after orchectomy is considered evidence of subclinical metastasis when other examination for this is negative.

There are surprisingly few reports in the literature pertaining to teratoma of the testicle metastasizing to bone. Geschickter states that only one instance (to the frontal bone) occurred in forty-two cases registered at the Johns Hopkins Surgical Pathological Laboratory. Eisendrath has reported a case of a malignant mixed tumor of an undescended testicle, which metastasized to the femoral head, and was discovered through bone destruction a year after removal of the primary tumor. Reports of metastasis to or about the spine are rare. Bricka and Pons report a case of a male twenty-seven years old, whose left testicle had been removed. One year later a large mass was present in the left side of the abdomen and flank. At autopsy this tumor was found to have been teratomatous. Kennedy and Stevenson report a case of teratoma of the left testis, which metastasized to the anterolateral aspect of the vertebral column in the lower dorsal area, invaded the tenth dorsal body, and produced necrosis of the cord distal to this level.

The following case of testicular teratoma, metastasizing to the spine with resulting paraplegia and sensory loss below the level of the involvement of the spinal cord, is reported as unusual. The authors feel it should be of interest to orthopaedic surgeons who find themselves confronted by the same situation, and may warn them that they are dealing, not with a simple compression fracture, but rather with a pathological one.

CASE REPORT

R. C., twenty-four years of age, a white male, was seen on February 12, 1940, with a complaint of pain in the lumbar and lower thoracic regions of the back. The onset of

his complaints followed a fall on January 17, 1940. The patient had been carrying a heavy automobile battery and had fallen a short distance, striking the buttocks. For about one month he had been receiving ambulatory treatment without benefit, and the back pain had increased in severity. Roentgenograms on February 12 (Fig. 1) revealed the presence of a compression fracture of moderate degree, involving the eleventh thoracic vertebra. Compression was of the wedge type with no posterior protrusion. Anteroposterior projections showed no lateral wedging and there was no evidence of fracture of the laminae or pedicles. Clinical examination revealed bilateral muscle spasm at the level of the thoracolumbar junction and localized tenderness over the eleventh thoracic spinous process. At this time there were no symptoms referable to the central nervous system, nor were there any objective neurological findings.

The right testicle was considerably enlarged. This was said to have been present for six years, following trauma to that testicle in a football game. The patient asserted that the mass had not increased in size, had never been productive of pain, nor caused discomfort of any nature. On examination the mass measured fifteen by ten by ten centimeters, was not nodular, was of a uniformly firm consistency, and was not tender. It did not transilluminate and there was no enlargement of the regional lymph nodes.

He was referred to the hospital where on the following day under general anaesthesia reduction of the compression fracture by hyperextension was done. A check roentgenogram revealed the compression had been entirely corrected (Fig. 2). A plaster jacket extending from the sternal notch to the symphysis ossium pubis was applied in the usual

FIG. 1

Compression fracture of the eleventh thoracic vertebra before manipulation.

FIG. 2

Compression fracture of the eleventh thoracic vertebra after reduction.

manner, the patient resting prone on the swathe. On recovering consciousness, the patient complained of numbness of his legs and inability to move them. The plaster jacket was immediately removed. On neurological examination it was found that there was complete flaccid paralysis of the lower extremities and the abdominal muscles, and loss of function of the rectum and bladder. There was complete loss of superficial sensation below the level of the twelfth thoracic dermatome anteriorly and posteriorly. Deep sensibility was absent in the lower extremities up to, and including, the iliac crests.

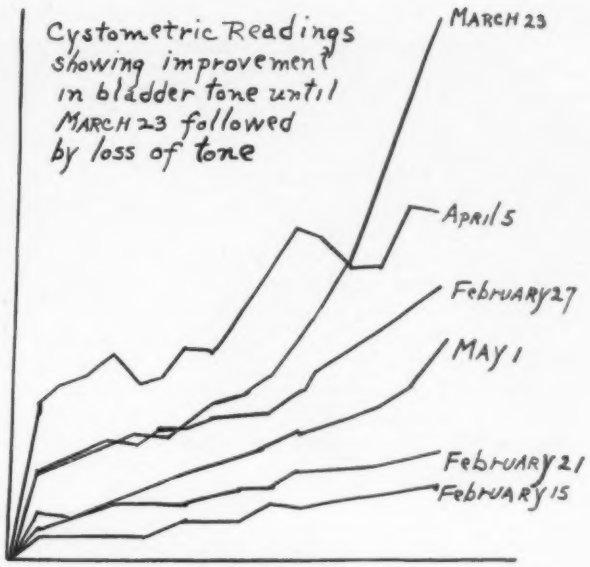

FIG. 3

Cystometric readings, showing improvement in bladder tone until March 23, followed by loss of tone.

A lumbar puncture was not done for several days because of the extreme tenderness of the back. At this time, roentgenograms were again taken and failed to show any evidence of dislocation. The neurosurgical consultant advised against surgery because of the lack of bony encroachment on the spinal canal. A cystometrogram showed that the bladder was atonic and tidal drainage was instituted. On February 21, a lumbar puncture revealed xanthochromic fluid with an initial pressure of 21 millimeters of water, prompt rise and fall with abdominal pressure, but no rise with jugular compression. There were no cells in the fluid; the Wassermann was negative; and the total protein was 95 milligrams per cent. Air myelography revealed a complete block at the lower border of the tenth thoracic vertebra. Because of the lack of clinical improvement a laminectomy from the ninth thoracic to the twelfth thoracic vertebrae inclusive was performed on February 23. The spinal cord was found markedly swollen opposite the tenth and eleventh thoracic spinous processes. There was no evidence of tumor, fracture of bony structures, or posteriorly protruding intervetebral disc. Following operation some sensory return occurred,—spotty and indefinite in nature. Motor function failed to return at any time. Bladder function improved as evidenced by weekly cystometrogram determinations (Fig. 3). However, after several weeks the bladder returned to its atonic state, probably on account of a complicating low-grade urinary infection. In spite of careful nursing, the usual decubitus ulcers over the sacrum and greater trochanters occurred. Ten weeks following operation, the patient developed evidence of nerve-root irritation, evidenced by hypersensitivity from the region of the left shoulder to the upper abdomen. On repeated lumbar punctures the spinal block continued, along with an increase in the total protein content of the spinal fluid. A short time later a mass was noticed to the left of the seventh thoracic spinous process. A roentgenogram (Fig. 4) taken at this time, June 4, indicated a sharply defined, homogeneous, soft-tissue shadow, extending from the seventh to the twelfth thoracic vertebrae, and varying from six to ten centimeters in width. A lateral view indicated that compression of the eleventh thoracic vertebral body had recurred and progressed (Fig. 5). Aspiration of the mass was done and a few drops of mucoid material was obtained. This was reported to be myxoma. The existence of a neoplasm at and about

FIG. 5

Compression fracture of the eleventh thoracic vertebra, showing recurrence of compression after removal of hyperextension jacket.

FIG. 4

Anteroposterior roentgenogram showing soft-tissue shadow of tumor three and one-half months following paralysis.

the fracture site, secondary to the testicular mass, was considered probable. An Aschheim-Zondek test was done, but on account of the infected urine the animal died. In view of the continuation of severe root pain uncontrolled by opiates, a chordotomy in the upper thoracic region was performed as a palliative measure on July 3. At this operation no effort was made to re-explore the lower thoracic laminectomy, and no evidence of neoplasm or other abnormality was found at the time of the second operation. After several days the root pains were relieved. Subsequent to this operation, the patient developed bronchopneumonia and died July 24, 1940.

AUTOPSY RECORD

Right Scrotum. The right testicle was markedly enlarged. On section (Fig. 6) a tumor was found which was apparently composed of many different kinds of tissue (Figs. 7 and 8). A portion of the mass contained what appeared to be cartilage; the remainder of the specimen presented a large amount of necrosis. The tumor mass extended upward to involve the spermatic cord.

Back. The scars of two laminectomies were present (upper and lower thoracic regions). There was a small sinus opening in the skin at the level of the fifth thoracic vertebra. Beneath the site of the lower laminectomy was a firm grayish-white tumor mass which apparently infiltrated the musculature of the back. It extended from the eighth thoracic to the region of the first and second lumbar vertebrae. It extended

FIG. 6

Gross specimen of testicle and lumbar muscles.

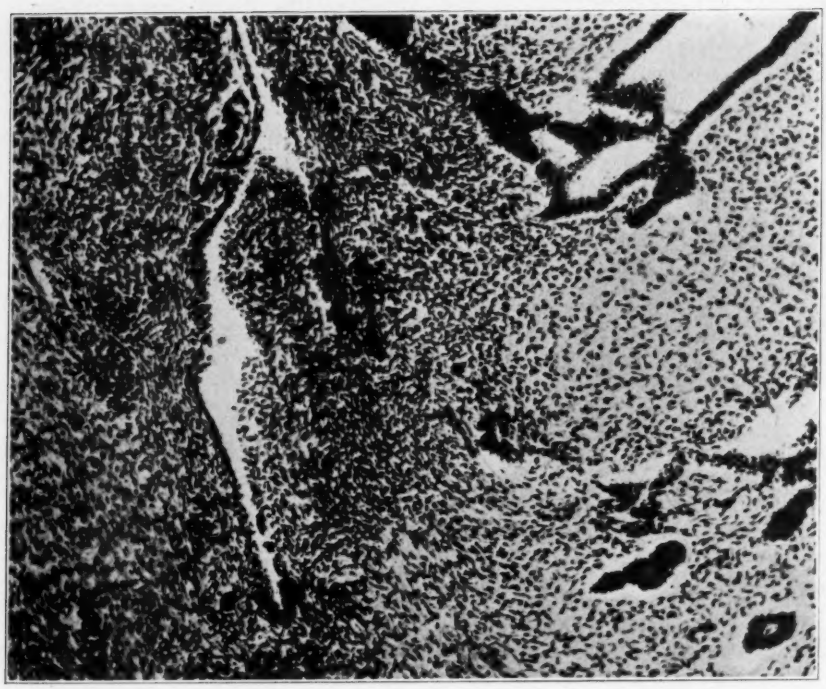

FIG. 8

Photomicrograph of testicular tumor, showing epithelial structure with myxomatous and sarcomatous stroma. (× 115.)

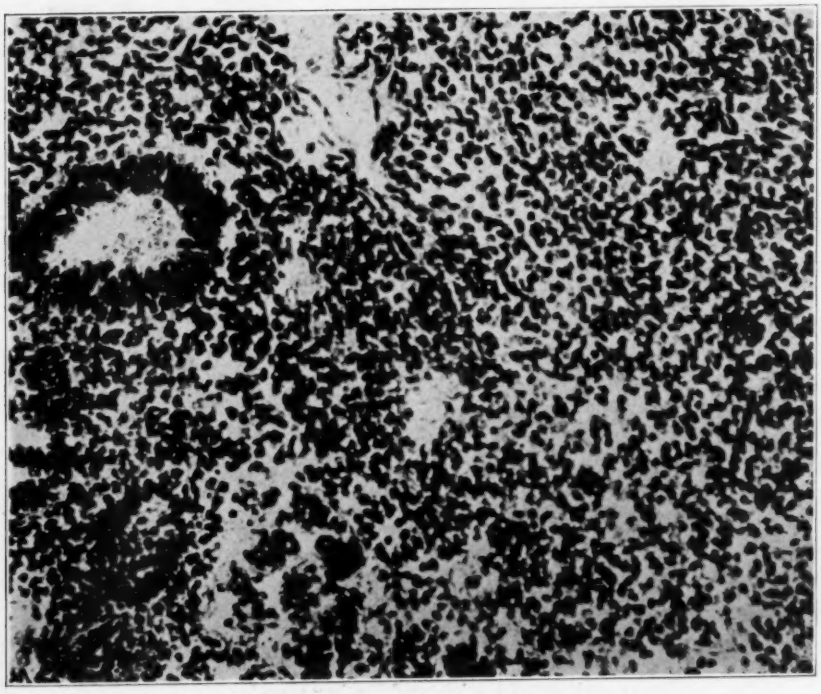

FIG. 7

Photomicrograph of testicular tumor, showing variation in epithelial structure. (× 280.)

FIG. 10
Photomicrograph of metastasis in bone. (× 125.)

FIG. 9
Photomicrograph of metastasis in spinal cord. (× 63.)

about seven centimeters to the left of the mid-line, and almost the same distance to the right. The tumor extended completely around the cord (Fig. 9) at the level of the eleventh thoracic vertebra, the body of which had been partially destroyed (Fig. 10). The spinal cord between the levels of the fourth and fifth cervical vertebrae contained some sutures (site of chordotomy). The area surrounding the cord at this point was dark red and soft. Some red fluid was present.

Microscopic Diagnosis. Teratoma (embryoma) of right testicle with metastasis to vertebrae of the upper lumbar, and lower and mid-thoracic regions.

CONCLUSIONS

From a review of the literature, it was found that teratomata with this type of metastasis—teratoma of the right testicle with metastasis to the vertebrae, paravertebral structures, and spinal cord—are rare. The unusual features in this case are as follows:

1. The length of time the mass in the testicle had been known to have existed (six years).
2. Trauma sufficient to cause a compression fracture of the spine preceded the onset of symptoms.
3. Absence of evidence of invasion of the central or peripheral nervous systems up to the time the compression fracture was reduced.
4. Absence of evidence of involvement of bone or the spinal cord at the time of the first laminectomy.
5. Lack of roentgenographic evidence of the true pathological nature of the involved vertebrae at the first examination.

REFERENCES

1. Bosworth, N. L.: A Review of Recent Literature on Tumors of the Testicle. Kentucky Med. J., XXXVI, 248, 1938.
2. Bricka, et Pons, Henri: Un cas de tumeur tridermique de la région prévertébrale secondaire à une tumeur du testicule. Marseille Méd., XL, 741, 1903.
3. Eisendrath, D. N.: Primary Tumor of the Testis; Metastasis in Head of Femur. Ann. Surg., XLI, 799, 1905.
4. Geschickter, C. F., and Copeland, M. M.: Tumors of Bone, p. 519. New York, The American Journal of Cancer, 1931.
5. Kennedy, Foster, and Stevenson, Lewis: Testicular Teratoma with Secondary Deposits in the Spinal Column and Meninges. Arch. Neurol. and Psychiat., XI, 151, 1924.

INTERCONDYLAR T FRACTURE OF ELBOW

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For the treatment of intercondylar or T fracture of the elbow, Miller has suggested nailing the fragments and Reich has advocated traction, both of which methods undoubtedly will produce excellent results in many cases. Manipulation and closed reduction are always the method of choice, provided reduction can be obtained by this means.

This report presents a case of a T-shaped fracture of the elbow treated by closed reduction. The case is interesting, because the roentgenograms were misinterpreted by a number of competent roentgenologists. A careful study of the films, however, showed the correct relationship of the fragments, and closed manipulation, together with lateral compression of the elbow by means of a carpenter's clamp, resulted in a good alignment and a useful elbow.

CASE REPORT

The patient was a young girl of sixteen, who sustained a severe injury of the right elbow as a result of a fall from a bicycle. Roentgenograms (Figs. 1-A and 1-B) showed an intercondylar, T-shaped fracture of the lower end of the humerus, with rotation and displacement of the inner portion of the lower fragment, and some ulnar displacement of the outer portion. The first interpretation considered the lower articular surface to be lines *F E* and *D G*. The actual fracture surfaces are *A B* and *C D* and the margin of the lower articular surface of the trochlea and radial head are *E B* and *D G*. The surface *E F* is the margin of the internal condyle.

FIG. 1-A

FIG. 1-B

Intercondylar T-shaped fracture of the lower end of the humerus, with rotation of the inner fragment, and ulnar displacement of the outer fragment.

FIG. 2-A

FIG. 2-B

After manipulation the alignment is restored, but the inner fragment is displaced medially, and the metaphyseal portion is separated from the shaft of the humerus.

Under local anaesthesia an attempt was made to rotate the inner fragment by manipulation and thus approximate surfaces *A B* and *C D*, and place the elbow in acute flexion. Check-up roentgenograms showed an apparent normal relationship, but a definite separation of the two fragments; an oblique view (Fig. 2-B) showed that the metaphyseal portion of the lower fragment was separated quite a distance from the shaft, and the problem arose as to what was the best method of approximating the fragments. (In a somewhat similar situation, Dr. Wolfert used a carpenter's clamp in a case presented by him at a clinical meeting at the Hospital for Joint Diseases, and an excellent result was obtained.) A carpenter's clamp as seen in Figure 3 was then applied, over felt pads, to the lateral margin of the elbow joint, and fixed by means of a flannel bandage suspended from the neck. By grad-

FIG. 3

Carpenter's clamp is applied over the condyles of the humerus.

FIG. 4-A FIG. 4-B

Five months after institution of treatment, showing satisfactory alignment at the lower end of the humerus.

ually tightening the clamp, the fragments were slowly approximated. The patient was instructed to tighten the clamp daily to the amount of compression which she could endure without too much discomfort. No nerve injury resulted from the compression.

Roentgenograms were taken with the clamp *in situ* after lateral compression had been employed for several days. The opposing fractured surfaces were then in almost complete apposition, and the rotation had been almost completely corrected. The clamp was maintained for four weeks.

After removal of the clamp, physiotherapy was instituted, with the elbow gradually flexed and extended, until, after three months of active treatment, extension was possible to 170 degrees and flexion to 45 degrees, the tips of the fingers just reaching the shoulder. Roentgenograms (Figs. 4-A and 4-B), taken five months after the injury, showed good alignment of the fragments.

REFERENCES

MILLER, O. L.: Blind Nailing of the T Fracture of the Lower End of the Humerus Which Involves the Joint. J. Bone and Joint Surg., XXI, 933, Oct. 1939.

REICH, R. S.: Treatment of Intercondylar Fractures of the Elbow by Means of Traction. J. Bone and Joint Surg., XVIII, 997, Oct. 1936.

A SPLINT TO INCREASE HIP AND KNEE MOTION

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The splint described is a modification of the half-ring leg splint. The main feature of the modified splint is the maximum degree of hip and knee motion that is possible with its use. The splint was first used in connection with the postoperative treatment of patients upon whom vitallium-cup arthroplasty had been done, and in whom as much hip motion as possible was desired. It is also of value in knee cases, since any method that increases hip flexion obviously increases knee flexion.

The splint is simple in construction (Figs. 1 and 2). It may be used on either the right or left side by making the proximal and distal half rings hinged. The standard Pearson attachment or one of its modifications can be used to complete the splint. The patient's hip and knee are first exercised passively, and then, as muscle tone increases, actively (Fig. 3).

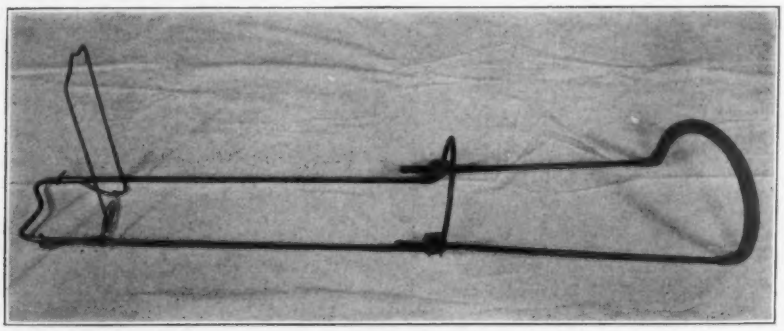


FIG. 1

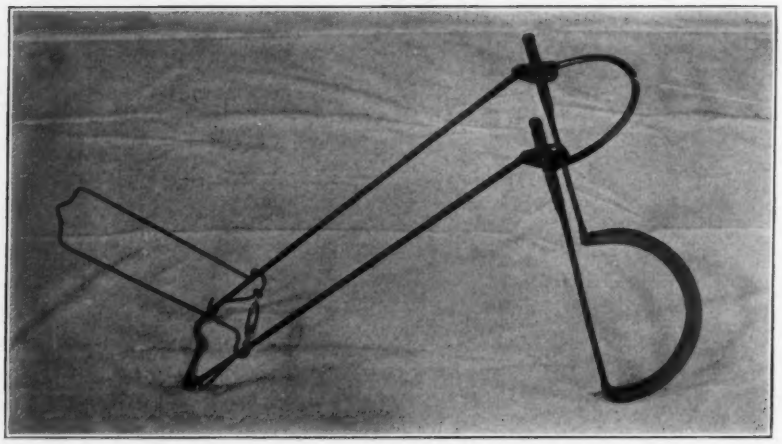


FIG. 2

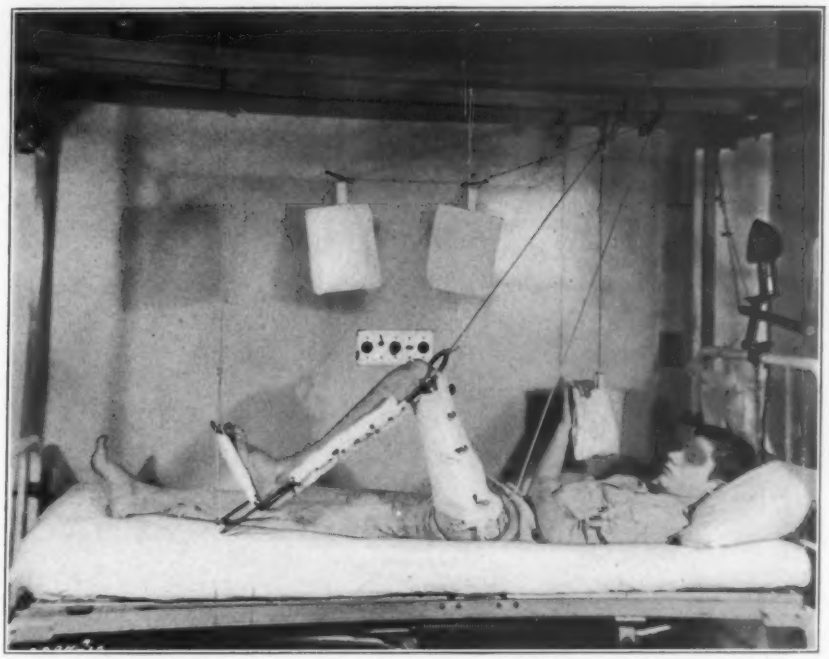
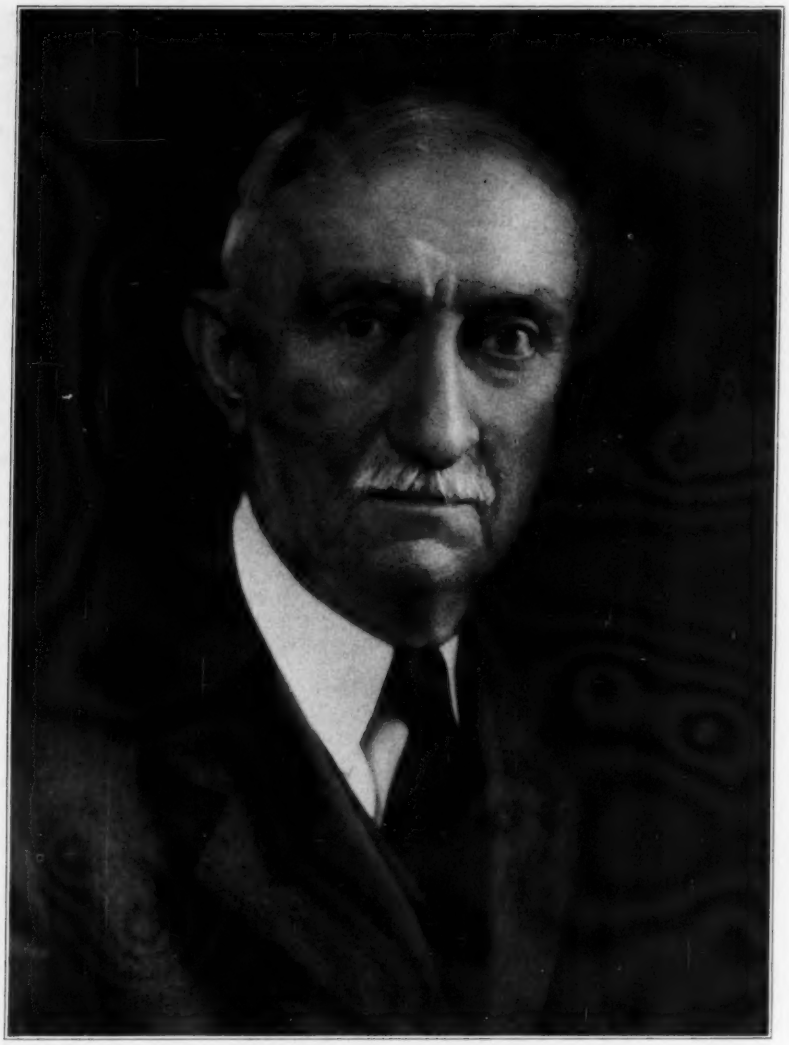


FIG. 3

FIG. 4

The stiffening of the knee and hip joint that often exists after prolonged immobilization in a plaster cast, requires many weeks of additional treatment before a good range of motion is regained. Often it is desirable to have some form of additional external support for the femur, as in the case of fractures of the femoral shaft. A canvas support with aluminum coaptation splints around the thigh might be used. Figure 4 shows the canvas support for the right thigh. This modified splint can be used for any condition about the hip and knee, in which early and full range of motion is the desired goal.

The author wishes to acknowledge the contribution by Dr. Carter R. Rowe in the original modification and early use of the splint.



AURELIUS RIVES SHANDS

1860–1941

Aurelius Rives Shands was born on November 5, 1860, in Prince George County, Virginia. He received his education in the South, where he attended McCabe's University School in Petersburg, Virginia, and later, the University Medical College (now the University of Maryland) in Baltimore.

After graduating in medicine in 1884, Dr. Shands established himself in Charles City County, Virginia, and engaged in general practice until 1892. He had become interested in orthopaedic surgery, which at that time was a limited but rapidly developing specialty in medicine and had but very few representatives in the South. He decided to train himself for this work and accordingly went to the Hospital for the Ruptured and Crippled in New York, serving first as a substitute intern and then as a regular intern during the year 1893, under the direction of Dr. Virgil P. Gibney. After completing his service there, he moved to Washington, D. C., where he started his practice of ortho-

paedic surgery and took an active and important part in placing this specialty in a recognized position in that city and in that part of the country.

The esteem in which Dr. Shands was regarded by his associates is indicated by the many positions of public service which he held. He was Professor of Orthopaedic Surgery at George Washington University, and later was made Clinical Professor in that same University. He was also Professor of Orthopaedic Surgery at the University of Vermont from 1900 to 1911. He was one of the founders of the New Emergency Hospital in Washington, of which he was Chief of the Orthopaedic Service, and Secretary of the staff for many years.

He was a member of the Virginia State Medical Society, and he held the position of Vice-President of the District of Columbia Medical Society in 1902. He was Chairman of the Committee of Arrangements in Washington of the Congress of Physicians and Surgeons from 1900 to 1933, and he served as President of the Alumni Association of the Hospital for the Ruptured and Crippled in 1918. He was a Founder Member of the American College of Surgeons. He was also an Emeritus Member of the American Academy of Orthopaedic Surgeons.

Dr. Shands was elected a member of the American Orthopaedic Association in 1896 and served as its President in the year 1912–1913. He always participated in the affairs of the Association, both in the presentation and discussion of papers and in the administrative deliberations. Members always looked forward to meeting him.

He was influential in establishing orthopaedic surgery in its recognized position in the South, and always took an active part in this specialty until about three years ago when he retired to his farm in Virginia, which he had made his hobby and in which he was always interested. He died in Washington, April 27, 1941.

He was never a prolific writer, but contributed largely to some of the more important subjects which in that period needed development by the guidance of men of judgment and experience. Among the subjects on which he wrote were Pott's disease, club-foot, hip-joint fractures, et cetera, and his experience added value to all of his literary contributions.

Dr. Shands was a man of strong convictions, but was never intrusive. He had much of the courtesy of former generations and gave to those with whom he came in contact the feeling of the dignity of the "old school", with the hospitality of the South. He was a pioneer in his specialty in Washington and in the South, and in a quiet way represented the best in orthopaedic surgery in his section of the country.

His loss is realized by those who knew him in the period of his active service, and he was one of the members of the Association who will be greatly missed.

WILLIS COHOON CAMPBELL

1880–1941

In the death of Willis Cohoon Campbell, May 4, 1941, in Chicago, orthopaedic surgery has lost one of its most active members and greatest leaders. He was born in Jackson, Mississippi, on December 18, 1880. He is survived by his wife, the former Elizabeth Yerger, whom he married in 1908.

His early education was received in his native state; his college and premedical training were taken at Hampden-Sydney College, Roanoke College; and his medical work, at the University of Virginia where he was graduated in 1904. After two years of internship, he entered the practice of medicine in Memphis. He early became interested in orthopaedic surgery, and, surmounting many hardships, he went to Europe to undertake the study of the specialty. He studied in London and Vienna, and had further postgraduate study in New York and Boston with the celebrated orthopaedic surgeons in this country at that time. He returned to Memphis in 1909 and resumed his practice, specializing in orthopaedic surgery.

In 1910 he was asked to organize a Department of Orthopaedic Surgery at the University of Tennessee Medical School and he became the first Professor of Orthopaedic Surgery in this institution, which office he held with distinction until his death. His

work in teaching was characterized by his desire to improve the teaching of orthopaedic surgery and postgraduate training.

Dr. Campbell realized the need for properly organized and conducted institutions for the care of indigent cripples, and he was one of the first to establish a crippled children's hospital school in that part of the South. After the establishment of the Crippled Children's Hospital School, he devoted his energy to the formation of a similar type of institution to continue the work for crippled children after they had passed childhood. He cherished the hope that some day he would see the foundation of an institution for the care of adult orthopaedic patients. With the cooperation of some of his close friends, this hope was realized in 1923 with the establishment of the Hospital for Crippled Adults.

In 1920 he built and opened the Willis C. Campbell Clinic, an institution for the care of his private patients and for the postgraduate training of men desiring to specialize in orthopaedic surgery. The fellowships in orthopaedic surgery which he started in connection with the Willis C. Campbell Clinic in 1924 provided essentially the same training required by the American Board for the Certification of Specialists.

Dr. Campbell was an active member of all of the societies in his specialty and many of the general surgical societies. Among the societies of which he was President are the following: Memphis and Shelby County Medical Society, 1921; Clinical Orthopaedic Society, 1928; American Orthopaedic Association, 1931; and Southeastern Surgical Congress, 1933. He was a member of the Board of Governors of the American College of Surgeons, 1936–1939, and of the House of Delegates of the American Medical Association, 1939–1940. His other professional affiliations included active and honorary membership in many American and foreign societies.

Dr. Campbell played an important rôle in the formation of the American Board of Orthopaedic Surgery and devoted many hours of thought to the problems incident to it. He served as a member of the examining board and was President from 1937 to 1940.

In conjunction with a number of his colleagues, Dr. Campbell envisioned the necessity for an organization in which younger men might receive recognition and identification which would guide their development. It was for this purpose that the American Academy of Orthopaedic Surgeons was founded, and its existence is very largely due to Dr. Campbell who was honored by being made its first President in 1933, and he lived to see the influence which this society in conjunction with the American Orthopaedic Association has exerted in welding the present standards of the specialty.

His capacity for work was almost superhuman, and his interests were widely distributed. He contributed many articles to scientific programs and to various medical journals, also chapters on orthopaedic surgery in many leading textbooks of surgery. In addition to this, he published three volumes: (1) a monograph, "Orthopaedics of Childhood", 1927; (2) a textbook, "Orthopaedic Surgery", 1930; and (3) his last publication, "Operative Orthopaedics", in 1939.

He was one of the pioneers in the development of arthroplasties. He had perhaps the greatest experience in his work on arthroplasty of the knee, and he contributed extensively by his experience with the massive onlay bone graft. Among his original contributions to the specialty perhaps the best known is his bone-block operation for paralytic drop-foot. He was a great believer in the careful analysis of end results and some of his most outstanding contributions to the advancement and development of orthopaedic surgery were contained in the published results of his vast experience.

To enumerate Dr. Campbell's scientific attainments would be to tell the story of only a small part of his full life. He extended kindly and loving guidance over all of the younger men with whom he came in contact; they were inspired by his honesty and integrity, by his unbounded zeal and enthusiasm, by the soundness of his judgment, and by the dominant will with which he overcame obstacles. The words of one of his friends expresses his feeling for him: "To know him was to love him, for his magnetic charm, his sincerety, his strong sense of fairness, and his unfailing kindness and courtesy endeared him to all who came within his ken. Indeed, only a little with him, and one was convinced that here, indisputably, was greatness".

Dr. Campbell's work was his life and he gave his life to it.

WALTER G. STERN

1874–1941

Walter G. Stern was born on December 6, 1874, at Chattanooga, Tennessee, the son of Bernard Stern who took part in the German Revolution of 1848 and came to this country with General Karl Schurz. He received his premedical and his medical education at Western Reserve University, Cleveland, and had postgraduate instruction in orthopaedic surgery under Prof. Adolph Lorenz in Vienna, Austria. In May 1903, he married Miss Lora B. Baer, who with two children, Bernard B. Stern and Mrs. Marjorie R. Schweid, survive him.

In 1903, Dr. Stern started the Mount Sinai Hospital, Cleveland, in a small private house, with twelve beds, and from 1903 to 1935 he served as Orthopaedic Surgeon and Director of Orthopaedic Surgery to both the hospital and the dispensary of this Hospital. In 1907 he occupied the Chair of Orthopaedic Surgery in the Cleveland College of Physicians and Surgeons. About this time he introduced orthopaedic work into both the Rainbow Hospital at South Euclid and the Children's Fresh Air Camp, Cleveland, and when this latter institution was compelled to close its doors in 1908, he helped to found the Holy Cross Home for Crippled Children. In 1914 he became Consulting Orthopaedic Surgeon to the Gates Hospital for Crippled Children and the Elyria Memorial Hospital. At the time of his death he was Consulting Orthopaedic Surgeon to the Mount Sinai Hospital, St. John's Hospital, the Glenville Hospital, and the Bedford City Hospital, Bedford. He was also appointed Orthopaedic Surgeon to the Lutheran Hospital, Cleveland, in 1932.

Dr. Stern was a member of the American Academy of Orthopaedic Surgeons and of the International Society for Orthopaedic Surgery. In 1929 he was President of the Clinical Orthopaedic Society and Chairman of the Orthopaedic Section of the American Medical Association.

In 1907 Dr. Stern was elected to membership in the American Orthopaedic Association, in which society he took an active part, both in presenting papers and in discussions, in the scientific as well as the executive sessions. He was elected Vice-President of the Association in 1917.

His life is a record of many activities and of public service. He began his work in orthopaedic surgery in the early period of this specialty, at a time when it was difficult to obtain the recognition of its place in the field of surgery, and the position it holds today is due in large measure to the work of those men who, like Dr. Stern, established themselves in different parts of the country in the pioneer days of the specialty, and developed the centers of activity from which has spread the rapid growth of this special department of surgery. He was the author of numerous works on the subject of orthopaedic surgery, appearing in various orthopaedic publications within the last forty years.

One was always impressed by his remarkable activity and enthusiasm, and the intensity with which he gave himself to the work in which he was engaged and interested.

He attended the meeting of the American Medical Association in Cleveland and was planning to attend the meeting of the American Orthopaedic Association in Toronto, but died suddenly on the preceding Sunday, June 8.

News Notes

At Commencement at Bowdoin College on June 21, Dr. Murray S. Danforth, of Providence, Rhode Island, was given an honorary degree of Doctor of Science.

Dr. Edward L. Compere announces the association with him of Dr. Sam W. Banks in the practice of orthopaedic surgery. Their offices are in the Lake View Building, 116 South Michigan Boulevard, Chicago.

Dr. C. B. Francisco announces that his nephew, Dr. C. L. Francisco, is now associated with him in the practice of orthopaedic surgery, at 623 Argyle Building, Kansas City, Missouri.

Dr. Eben W. Fiske has moved his office to 725 Jenkins Arcade Building, Pittsburgh, Pennsylvania.

Dr. Theodore H. Vinke announces the association with him of Dr. Charles U. Hauser in the practice of orthopaedic surgery. Their office is Suite 709, Carew Tower, Cincinnati, Ohio.

Dr. Harold C. Bean, of Salem, Massachusetts, has been called to active duty in the Navy and is located at the United States Naval Hospital, Portsmouth, New Hampshire.

Dr. Louis W. Breck announces that Dr. W. Compere Basom is now associated with him in the practice of orthopaedic surgery. Their office is at 410 Roberts-Banner Building, El Paso, Texas.

The Walter M. Brickner Lecture at the **Hospital for Joint Diseases,** New York, was given on May 2 by Dr. Franklin C. McLean, Professor of Pathological Physiology, University of Chicago. His subject was, "Calcification and Ossification: Some Aspects of the Physiology of Bone".

The Twentieth Annual Conference of the **American Physiotherapy Association** is to be held at Lagunita Court, Stanford University, California, July 13 to 18.

The Seventieth Annual Meeting of the **American Public Health Association** will be held at Atlantic City, New Jersey, October 14 to 17. Headquarters for the meeting will be the Convention Hall, and residence headquarters will be the Hotel Traymore.

The Fifth Semi-Annual Meeting of the **Tri-State Orthopedic Society** was held in Fort Wayne, Indiana, on April 19. An interesting program was presented by the orthopaedic surgeons of Fort Wayne and Indianapolis. The next meeting will be held in Cincinnati, Ohio, in September.

The **American Society for the Study of Arthritis** held its Twelfth Annual Meeting on June 5, 6, and 7, at the Deshler-Wallick Hotel, Columbus, Ohio. An excellent program was presented, of special interest being papers by Dr. Edward Harlan Wilson, "Surgical Aspects of Arthritis"; Dr. W. W. Lermann, "Relation of the Gastro-Intestinal Tract to Arthritis", a study based on 5,000 cases; Dr. Reginald Burbank, "Bacteriological and Serological Approach to Diagnosis and Treatment of Arthritis"; and a report on "Chemical Investigations" by Dr. Roland Davison.

The **International College of Surgeons** will hold its Annual International Assembly in Mexico City, August 10 to 14, in response to the invitation of the Mexican Government. Many of the Pan-American countries will send official representatives; sessions will be conducted in both English and Spanish. It is expected that surgeons from England, Holland, Palestine, Portugal, Switzerland, and Turkey will also participate in the meeting. Information about the meeting may be obtained from Dr. Max Thorek, Executive Secretary, 850 West Irving Park Boulevard, Chicago.

The **New England Society of Bone and Joint Surgery** has been formed. Its membership is limited to those surgeons in the New England States who confine their practice to bone and joint surgery, particularly the problems of traumatic surgery. The purpose of the Society is to aid in the advancement in the methods of treatment of these conditions. The membership at present is limited to thirty-five active members. The Society will hold professional and scientific meetings in various centers in New England. The first meeting was held in Boston, June 25, 1941. The officers are: President, Dr. A. Leo Brett; Vice-President, Dr. Joseph S. Barr; Secretary-Treasurer, Dr. Gordon M. Morrison.

On May 27, Dr. Arthur Steindler was honored by an all-day clinic and day of social activities, attended by former assistants and members of the staff of the Department of Orthopaedic Surgery of the State University of Iowa. The gathering included orthopaedic surgeons from all parts of the United States. At this time, a permanent Steindler Alumni Club was formed, which plans to meet annually at the time of the meeting of the American Academy of Orthopaedic Surgeons.

The special feature of the occasion, marking the completion of twenty-nine years of his teaching at the University, was the unveiling and presentation to the University of the portrait of Dr. Steindler, Professor and Head of the Department of Orthopaedic Surgery. The portrait, painted by Sidney Dickinson, was the gift of former students and present staff members. It was presented at a banquet, attended by 265 colleagues and friends, and was accepted by President Virgil M. Hancher of the University.

BRITISH ORTHOPAEDIC ASSOCIATION

The postponed 1940 Annual Meeting of the British Orthopaedic Association was held in Oxford on January 3, 1941, under the Presidency of Prof. T. P. McMurray. The Association dinner was held the same evening at New College. Among many distinguished guests were Sir Farquhar Buzzard, the Vice Warden of New College, Colonel Hugh Cairns, Dr. Charles Bradford, and other members of the American Hospital in Britain.

The meeting, which was well attended, despite severe winter weather and difficulties of travel, was devoted to the presentation of short papers of which the following is a summary:

LATE RESULTS OF FRACTURE OF THE NECK OF THE FEMUR. By Mr. A. L. Eyre-Brook and Mr. K. H. Pridie, Bristol.

Forty-seven patients out of a total of seventy-five treated for fracture of the neck of the femur by manipulative reduction and the insertion of a Smith-Petersen nail by the Hey Groves technique had been reviewed by clinical and roentgenographic examination at least one year after the procedure. Bony union was proved in 58 per cent. of patients. In the whole series of seventy-five, there had been a mortality of 5.3 per cent. Aseptic necrosis of the capital fragment had occurred more frequently in patients under thirty years of age. The importance of the fracture-shaft angle of Pauwels was emphasized. If this angle was low (below 30 degrees), the results from nailing alone were poor. It was concluded that a fibular graft should be inserted as well.

THE INDICATIONS FOR EXCISION OF THE PATELLA. By Mr. Norman Roberts, Liverpool.

This communication was based on twenty patients in whom the patella had been excised. He discussed the uses of the patella and emphasized the following points:

1. Recovery of function after excision is not so rapid as is often thought, though it is more rapid than after suture of the patella.

2. After excision, flexion movement is usually full or is possible to at least a right angle; extension is often limited; and the quadriceps is often weaker than normal.

3. Excision is advisable in all comminuted fractures in both young and old patients, and in transverse fractures in middle-aged and old patients.

4. Transverse fractures in young patients should be sutured. If the fragments are markedly unequal in size, it is easier to excise the smaller fragment and to suture the rectus or patellar tendon efficiently to the larger fragment.

5. Derangement of the knee, due to recurrent dislocation of the patella, cannot usually be cured by excision of the patella.

6. Good results sometimes, but not always, follow excision in osteo-arthritis of the knee, particularly if the arthritic changes are mainly in the patellofemoral compartment of the joint.

THE CORRECTION OF SCOLIOSIS. By Mr. G. E. Thomas, Liverpool.

Correction of the deformity had been achieved in the majority of sixteen patients by recumbency on a Thomas frame with longitudinal traction and countertraction applied to the head and legs and "three-point" pressure on the apex of the convexity and the extremities of the concavity. To exert lateral pressure, special pads operated slowly by a screw mechanism of the Thomas-wrench type was employed. Failure to achieve correction had occurred in very high and very low curves; in severe, long-established curves; and in those cases in which there was gross rotation, out of all proportion to the lateral curvature.

TREATMENT OF FRACTURES OF THE EXTERNAL TUBEROSITY OF THE TIBIA. By Mr. W. S. Diggle, Liverpool.

Mr. Diggle reviewed a series of these difficult fractures. For those cases in which there was gross comminution and depression of the fragments, he had found open operation, replacement of the fragments, and screw fixation the most effective treatment. Most of his patients treated in this way had been able to return to work in about six months.

TREATMENT OF COMPOUND FRACTURES OF THE LEG. By Mr. G. K. McKee, Norwich.

The speaker advocated fixed skeletal traction on a Thomas splint for tibial and femoral fractures, both simple and compound. For tibial fractures a Steinmann pin was inserted transversely through the upper tibial fragment and through the os calcis or the lower fragment. The pins were fixed firmly, after reduction by manual traction, to the lateral bars of the Thomas splint by a spiecal clamping device.

For femoral-shaft fractures, one pin was employed below the fracture, fixed in a similar way to the Thomas splint. To avoid undue pressure on the ischial tuberosity or groin, the splint was tied to the end of the bed which was then elevated.

The advantage of this method, in contrast to the "closed-plaster" technique, was discussed in the light of a successful experience with the former on thirty compound and twenty simple fractures.

KIENBÖCK'S DISEASE AND ITS TREATMENT. By Mr. F. C. Dwyer, Liverpool.

The author considered that this peculiar affection of the carpal semilunar is probably due to a fibrosis of the dorsal ligaments attached to the bone, resulting usually from trauma. From an experience with thirty-four patients, in ten of whom the damaged semilunar had been removed, Mr. Dwyer felt that conservative treatment offered the optimum results in a condition which in any event always resulted in a permanently damaged wrist.

NERVE REGENERATION AND NERVE GRAFTING. By Mr. J. L. Young, M.A., Oxford.

In a most stimulating discourse Mr. Young outlined the preliminary results of the experimental work, now in progress at the University of Oxford, on nerve regeneration and nerve grafting in rabbits. At the start he warned against complete application of the experimental findings to man, even though they had been very accurately demonstrated in animals.

The need for a qualitative method of comparison between different procedures for nerve repair was emphasized. The rate of growth of new fibers was adopted as a criterion, and a method of estimating it was developed. The rate for rabbits was found to be about four millimeters a day, was the same in all nerves, and approximately the same at all levels. Certain suture material occasioned severe reactions,—for example, catgut and pigmented silk. White silk, woman's-hair sutures, and fibrin "glue" produced the least reaction. Return of function was often rapid, and it was emphasized that such rapid recoveries occurred after full wallerian degeneration,—they were not due to "physiological interruptions" such as can occur after ischaemia, but which clear up even more rapidly. Mr. Young pointed out that the delay between interruption and recovery of a nerve's conduction has three parts:

1. In the juncture scar,—probably about twenty days in man.
2. In the nerve itself, during the growth of fibers down it,—probably at the rate of 2.5 millimeters a day in man.

These two phases comprise the anatomical delay.

3. In the muscle, the functional delay,—about forty to sixty days in man. The delay in the muscle seems to be shorter if the muscle has been denervated for only a short time,—a finding strongly in favor of early suture.

The problems of bridging gaps were discussed. It had been demonstrated that nerves could not be stretched suddenly more than 10 per cent. of their total length; and that increase in length from gradual stretching probably was due to actual growth in length of the nerve, rather than to stretching. For grafting, autografts had given most success in rabbits, and there were some encouraging results from homografts.

It is impossible in this brief space to report adequately the many interesting points which Mr. Young raised. It is hoped that he and his coworkers will shortly publish the results of their studies in detail.

AMERICAN ORTHOPAEDIC ASSOCIATION

The Fifty-Fifth Annual Meeting of the American Orthopaedic Association was held in Toronto, Ontario, Canada, on June 9, 10, 11, and 12, 1941, under the Presidency of Dr. D. E. Robertson. The headquarters were the Royal York Hotel, and the sessions were held at Hart House, University of Toronto.

Monday and Tuesday mornings were devoted to clinical sessions arranged by the local committee, and cases were presented by the following: Dr. A. D. McLachlin, Dr. F. R. Wilkinson, Dr. S. A. Thomson, Dr. W. S. Keith, Dr. A. W. Farmer, Dr. J. L. McDonald, Dr. A. B. LeMesurier, Dr. D. E. Robertson, Dr. R. I. Harris, Dr. H. S. Coulthard, Dr. Gordon M. Dale, Dr. G. D. W. Murray, Dr. F. I. Lewis, Dr. K. G. McKenzie, and Dr. W. E. Gallie.

At the scientific sessions the following papers were presented:

TUESDAY, JUNE 10

Afternoon Session

President's Address.

Dr. D. E. Robertson, Toronto.

End-Result Study of the Treatment of Idiopathic Scoliosis.

The Research Committee of the Association—Dr. A. R. Shands, Jr., *Chairman*, Wilmington, Delaware; Dr. Joseph S. Barr, Boston, Massachusetts; Dr. Paul C.

Colonna, Oklahoma City, Oklahoma; and Dr. Lawrence Noall, Research Fellow of the Nemours Foundation, Wilmington, Delaware.

Valgus Deformity of the Knee Resulting from Injury to the Lower Femoral Epiphysis.
Dr. LeRoy C. Abbott, San Francisco, California.

Amputations for Arterial Disease.
Dr. Harry B. Macey, Rochester, Minnesota.
Discussion opened by Dr. A. B. LeMesurier, Toronto.

WEDNESDAY, JUNE 11

Morning Session

Surgical Stabilization of Paralytic Dislocated Hips.
Dr. Halford Hallock, New York, N. Y.
Discussion opened by Dr. R. I. Harris, Toronto.

Hospital Treatment of Chronic Rheumatism.
Dr. Robert B. Osgood, Boston, Massachusetts.
Discussion opened by Dr. J. Albert Key, St. Louis, Missouri.

The Treatment of Acute Osteomyelitis by the Sulfathiazole Drugs.
Dr. Robert W. Johnson, Jr., Baltimore, Maryland.
Discussion opened by Dr. Frank D. Dickson, Kansas City, Missouri.

Fractures and Fracture-Dislocations of the Astragalus.
Dr. Robert D. Schrock and Dr. Herman F. Johnson, Omaha, Nebraska.
Discussion opened by Dr. Oscar Lee Miller, Charlotte, North Carolina.

Treatment of Compound Fractures.
Dr. Philip D. Wilson, New York, N. Y.

Afternoon Session

Symposium on War Subjects.
The Red Cross and London, September, 1940.
Col. George Nasmith.
The Canadian Project for the Preparation of Dried Human Serum for Military Use.
Prof. C. H. Best.
Orthopaedic Experiences with Ex-Soldiers.
Dr. Ross Millar.
Experiences in England, 1940.
Dr. Philip D. Wilson.
Orthopaedics Relating to the United States Army.
Dr. George E. Bennett, Dr. Guy W. Leadbetter, and Col. Norman T. Kirk.
Other speakers in the Symposium were Dr. Gillies and Dr. Kelley.

THURSDAY, JUNE 12

Morning Session

Extension Deformities of the Cervical Spine.
Dr. Lloyd T. Brown, and Dr. John G. Kuhns, Boston, Massachusetts.
Discussion opened by Dr. A. Bruce Gill, Philadelphia, Pennsylvania.

Myxomatous Tumors of the Knee Joint.
Dr. Ralph K. Ghormley, and Dr. Malcolm B. Dockerty, Rochester, Minnesota.
Discussion opened by Dr. Allen F. Voshell, Baltimore, Maryland.

Resection and Transplantation in the Treatment of Bone Sarcomata.
Dr. Dallas B. Phemister, Chicago, Illinois.
Discussion opened by Dr. Willis K. West, Oklahoma City, Oklahoma.

Femoro-Ischial Transplant in Certain Cases of Tuberculosis of the Hips.
Dr. David M. Bosworth, New York, N. Y.
Discussion opened by Dr. Halford Hallock, New York, N. Y.

Vitallium-Mold Arthroplasty (moving-picture demonstration).
Dr. M. N. Smith-Petersen, Boston, Massachusetts.

The Annual Dinner was held at the Royal York Hotel, on Wednesday evening, June 11. The speaker of the evening was Sir Robert Falconer.

At the last Executive Session the following officers were elected:
President-Elect: Dr. Frank R. Ober, Boston, Massachusetts.
Vice-President: Dr. A. B. LeMesurier, Toronto.
Secretary: Dr. Charles W. Peabody, Detroit, Michigan.
Treasurer: Dr. Frank D. Dickson, Kansas City, Missouri.

The following members of committees and delegates were elected:
Membership Committee: Dr. Mather Cleveland, New York, N. Y.
Program Committee: Dr. Myron O. Henry, Minneapolis, Minnesota.
Delegate to the American College of Surgeons: Dr. James Archer O'Reilly, St. Louis, Missouri.
Representatives on the American Board of Orthopaedic Surgery: Dr. George E. Bennett and Dr. Allen F. Voshell, Baltimore, Maryland.

The President for the current year is Dr. George E. Bennett, Baltimore, Maryland. The 1942 meeting will be held in Baltimore, in May.

The following were elected to active membership in the Association:
Dr. Walter P. Blount, Milwaukee, Wisconsin.
Dr. Frederick C. Bost, San Francisco, California.
Dr. A. W. Farmer, Toronto.
Dr. P. M. Girard, Dallas, Texas.
Dr. R. Nelson Hatt, Springfield, Massachusetts.
Dr. Frederick A. Jostes, St. Louis, Missouri.
Dr. Beveridge H. Moore, Chicago, Illinois.
Dr. Jesse T. Nicholson, Philadelphia, Pennsylvania.
Dr. Eugene M. Regen, Nashville, Tennessee.
Dr. John A. Siegling, Urbana, Illinois.
Dr. Paul B. Steele, Pittsburgh, Pennsylvania.
Dr. T. Campbell Thompson, New York, N. Y.
Dr. R. M. Wansbrough, Toronto.
Dr. Edward Harlan Wilson, Columbus, Ohio.

On Tuesday evening a dinner was given at the Toronto Hunt Club by Dr. and Mrs. Robertson, an occasion greatly enjoyed by the members of the Association.

Those who attended the Meeting report that it was one of the best meetings of the Association ever held. Great credit is due the President and members of the Local Committee, Drs. LeMesurier, Farmer, Thomson, McDonald, and Harris, as well as the Program Committee of which Dr. Alan DeForest Smith was Chairman.

Current Literature

FRACTURES AND OTHER BONE AND JOINT INJURIES. R. Watson-Jones, B.Sc., M.Ch.Orth., F.R.C.S. Ed. 2. Baltimore, Williams and Wilkins Co., 1941. $13.50.

Of all of the comparatively numerous textbooks and volumes of reference on the subject of "fractures and other injuries to the bones and joints" which have appeared within the past ten years, none is more delightfully written or more stimulating in manner of presentation than is this scholarly work by Watson-Jones.

As stated by the author, the first edition of this book was written in days of relative peace. However, that volume included the tested and proved procedures through which the science of orthopaedic surgery, and particularly of fracture treatment, had advanced. This second edition includes material and information obtained by Watson-Jones, through his own experience and that of his colleagues, in rendering aid as civilian consultant orthopaedic surgeon to the Royal Air Force.

The chapter on open and infected fractures and war wounds has been rewritten. Recent developments in chemotherapy, blood and plasma transfusion, the treatment of wound shock, the closed-plaster technique, and the technique of amputation have been considered with finesse and clarity. The quality of the illustrations and of the printing, as was also true of the first edition, is so excellent that they are deserving of special comment. The physiology of the healing of a fracture is beautifully portrayed in a full-page colored photomicrograph, and there are other noteworthy illustrations in color.

After this book, there is little for the modern fracture surgeon to add to the subject. Whether used as a book of reference or a textbook, this is a volume of classical medical writing which will be a valuable and prized addition to the library of the doctor who has any interest in the treatment of fractures or other injuries to the bones or joints.

ARTHRITIS AND ALLIED CONDITIONS. Bernard I. Comroe, M.D. Ed. 2. Philadelphia, Lea & Febiger, 1941. $9.00.

The second edition of this book is better than the first. It has been amplified and brought up to date, especially in regard to gold therapy and sulfanilamide preparations as used today. The text is clear and simple. Many questions asked by the general practitioner have been answered in a practical way by the author's "box form" summaries which are excellent. These make the book very useful for quick reference on almost any subject connected with arthritis on which the physician may wish to refresh his memory.

As a textbook, it presents one of the best reviews so far published. All the usual forms of therapy as used by the experts are carefully described,—massage, baking, exercise, rest, splinting, and surgery. The more recent forms of treatment—such as gold, sulphur, and bee venom—are appraised and given to the reader to use as he wishes after knowing the opinion of the authorities on all the special subjects.

There are additional chapters on backache, feet, sciatica, shoulders, and tumors of the joints. A special chapter on the organization of an arthritic clinic is of real value to the hospital administrator.

The first edition found a place in American medical literature which should be made more secure by this improved second edition. It is well worthy of study by all physicians.

EMERGENCY SURGERY. Hamilton Bailey, F.R.C.S. Ed. 4. Baltimore, The Williams & Wilkins Co., 1940. $15.00.

This new edition contains all the good features of the previous editions plus many new ideas. The book is excellent in its clearness, simplicity, and excellence of illustrations. Being a treatise on "emergency surgery" it aims to portray the high lights of all procedures which may have to be done as emergencies. It is so carefully arranged and

indexed that one about to perform an emergency operation could look up the matter in question in a very few minutes.

This edition was published in Great Britain shortly after the onset of the War and for this reason does not contain any new points developed from war surgery. However, it does bring up to date all the new surgical procedures which are of such importance in war surgery. Some of the new subjects treated at length are: intravenous infusions, transfusions, typing, the use of stored blood, the use of the vacoliter and transfuso-vac, peripheral embolism, thrombosis and phlebitis, the use of sulfanilamide in gas gangrene and other infections, and the use of the Miller-Abbott tube.

All the major operative procedures are clearly discussed and illustrated by careful engravings. Many of the more important illustrations are in color. This is by all means the best edition thus far, and one of the finest books we have seen on surgical emergencies.

THE PHARMACOLOGY OF ANESTHETIC DRUGS. John Adriani, M.D. Ed. 2. Springfield, Illinois, Charles C. Thomas, 1941. $3.50.

The eighty-six-page syllabus on the pharmacology of anaesthetics is the first attempt to correlate the physical and theoretical with the clinical features of anaesthesia. It is a book of equal value to clinicians of medicine, surgery, and anaesthesia, and presents physiological and pathological effects of the drugs used in anaesthesia and general medicine on the various organs and systems of the body. The book consists of a compilation of valuable data from periodicals, textbooks, and other sources in the medical and scientific literature, as well as original clinical and laboratory investigation by the author and his collaborators. Many interesting charts and diagrams simplify the book and make it instructive and interesting.

The main issues under consideration are the pharmacology and chemistry of the anaesthetic and non-anaesthetic drugs employed in anaesthesia; the physiology of respiration, with reference to the pathological conditions arising during anaesthesia; the physiological and toxic effects of the gaseous volatile; aliphatic anaesthetic agents, and local anaesthetics used in regional anaesthesia. The use of stimulating drugs used as analeptics is considered separately, as is the use of the inorganic gases, such as oxygen and nitrogen, helium and carbon dioxide.

Other valuable data are presented on preanaesthetic medication, carbon dioxide absorption, complications and accidents during anaesthesia, postanaesthetic sequelae, and anaesthesia and respiratory complications. A section on fires and explosions with anaesthetics and a brief but very valuable bibliography makes the book complete.

DIE WIRBELTUBERKULOSE UND IHRE HEILUNG (Tuberculosis of the Spine and Its Cure). Dr. med. Julius Friedrich von Finck. Stuttgart, Ferdinand Enke, 1940. 19.60 marks.

Surrounded by the articulate champions of this and that new method, it seems almost superfluous to return to the study of old methods. There is nothing new in the treatment of tuberculosis, however, and the "old timers" had the advantage of seeing much more clinical material than we see today. From an experience of forty years in the conservative treatment of spinal tuberculosis in Russia and Germany, an almost legendary character now summarizes his life work in a monograph which many Americans will find at variance with their convictions. Before and after photographs and roentgenograms of *corrected* deformities compel one's attention to his aphorisms. Tuberculosis is carried to the spine through the lymphatics and usually appears first in the intervertebral disc, and should be treated by compression, not extension. The most important therapeutic measure is generalized muscle relaxation.

The use of plaster beds, with the "cotton cross" making pressure on the gibbus, is only one part of a painstaking technique which is of considerable practical importance to any orthopaedic surgeon. Long pointed to in Europe as a bulwark of steadfast conservatism, the work of von Finck is now recorded in readable form. It should be more than a valuable record to the next generation.

MASSAGE IN NURSING CARE. Kathryn L. Jensen-Nelson, M.A., R.N. Ed. 2. New York, The Macmillan Co., 1941, $2.00.

The first edition of this book appeared in 1932 under the more satisfactory title "Fundamentals of Massage" and, with some additions, contains "the essential facts in the science and art of massage which the author believes are fundamental in the education of any nurse". This new title "Massage in Nursing Care" is a misnomer, as it fails to cover the phases of massage which are required of the professional nurse.

Set up as a textbook, it assumes that the student nurse, in the minimum required time (seven hours of theory and eight periods in the laboratory) can master the theory and practice of the application of massage, as well as some of the active and passive movements, and learn to make intelligent decisions in arranging her own prescriptions for the treatment of many diseases of the muscular, circulatory, nervous, and gastro-intestinal systems. The brief and generalized descriptions of the care of conditions considered are only sufficient to give the nurse a prefatory interpretation of the value and application of this modality as a part of the treatment of the patient, and certainly should not be interpreted to be sufficient information to equip any worker to treat the various conditions described. The treatment of postural defects, sprains, fractures, arthritis, circulatory disturbances, poliomyelitis and other paralyses according to the standards for physical-therapy training approved by the Council on Medical Education of the American Medical Association, belongs in the hands of a specialist trained in physical therapy, and is not required of the attending nurse.

NOTFALLCHIRURGIE. DIE AUSFÜHRUNG DER DRINGLICHEN BLUTIGEN EINGRIFFE (Emergency Surgery). Priv.-Doz. Dr. Adolf Ritter. Stuttgart, Ferdinand Enke, 1940. 40.50 marks.

This text constitutes Band 63 of the system of *Neue Deutsche Chirurgie* appearing currently under the general editorial supervision of Sauerbruch. Primarily the work is intended for the general surgeon who is called upon to handle any emergency. The directions for the procedures recommended are interestingly presented in a concise form. The larger part of the work is devoted to subjects which do not especially concern the orthopaedic surgeon. The hundred or so pages which deal with orthopaedic problems are devoted mainly to the treatment of inflammatory conditions. Fractures are but sketchily discussed. The surgery of paralysis and of congenital malformations is, by the nature of the work, completely excluded.

THE AMERICAN ILLUSTRATED MEDICAL DICTIONARY. W. A. Newman Dorland, A.M., M.D., F.A.C.S., with the collaboration of E. C. L. Miller, M.D. Ed. 19. Philadelphia, W. B. Saunders Company, 1941. $7.00 (Thumb-Indexed, $7.50).

The Nineteenth Edition of this book has just appeared. Each edition is welcomed, because of the character and the amount of the new information which it always gives as well as the accuracy with which the advances in the different fields of medicine and surgery have been followed.

It is distinctly a word book, but it is very much more than a dictionary of medical terms and conditions, because of the large amount of information on the different subjects, which gives to the practitioners the data so frequently needed. Information in regard to laboratory methods, tests, etc., accompanies definitions. Under important headings a considerable amount of collateral descriptive matter is appended; for example, under drugs is given information in regard to their origin, their composition, dosage, etc.; under special diseases, information in regard to their etiology, clinical data, often with symptoms added; and this general principle is carried throughout the book in regard to all of the different headings and the later advances, to give more than merely suggestions of the progress in the latter years.

The important data in regard to the pronunciation, derivation, etc., are made a special feature, all of which afford in a brief and convenient form that knowledge of which the busy medical man is in constant need, and he will find the large amount of information contained in the book presented in a practical and convenient form. The illustrations, diagrams, and charts, of which there are a great many, add to the attractiveness and to the interest of the volume.

FIELD SURGERY IN TOTAL WAR. Douglas W. Jolly, M.B., Ch.B.N.Z. New York, Paul B. Hoeber, Inc., 1941. $3.50.

The author commanded a mobile surgical unit in the Spanish War, and the opinions expressed in this book are based on his personal observations of some 4,500 wounded men. The book is divided into two sections.

Section 1 covers the organization and tactical disposition of surgical units in the field. To overcome the "time lag", patients were evacuated to the "Classification Post", one to four miles behind the front. "First" urgency cases were despatched immediately to the adjacent No. 1 Hospitals which, to be effectual, had to be within the five-hour "time lag" from the front. No. 2 Hospitals, which were located farther to the rear, within a ten-hour "time lag", received all other cases except the slightly wounded and sick who were evacuated directly to the sector Evacuation Hospital located at a rail head. The "time lag" to this Hospital was under eighteen hours.

The mobile surgical unit was the basic unit of the three-point forward system. It consisted of a surgical lorry (*auto-chirugire*), and one ambulance for transportation of personnel,—used for evacuation of patients when the team was on station.

Section 2 (more than two-thirds of the book) covers the surgical technique used in the forward areas. The author classifies war wounds into two main groups: (a) those requiring immediate operation for the saving of life (at Hospital No. 1), and (b) those requiring operation as soon as possible for the shortening of the period of disability.

Various types of anaesthesia are discussed and contra-indications are considered. One chapter is devoted to each of the following: wounds of the nervous system; extremities; face, jaw, eye, ear, and neck; chest; abdomen; and genito-urinary system. Gunshot wounds of the abdomen are discussed in detail.

This is a very excellent reference book for the surgeon interested in the evacuation and emergency treatment of war wounds.

FRACTURAS RECIENTES DEL RAQUIS. ALGUNOS DE SUS ASPECTOS (Recent Fractures of the Spine). Dr. José Luis Bado. Montevideo, 1940.

This is a very well organized study of 117 cases of fracture of the spine with excellent illustrations, roentgenograms, colored line drawings, and photographs of post-mortem specimens of the spine, etc. The monograph of 152 pages, well printed on very good paper, is divided into several parts:

1. General statistical considerations;
2. Clinical varieties of fractures of the spine;
3. Treatment of recent vertebral fractures without involvement of the roots and spinal cord;
4. Inconveniences and complications of reduction in hyperextension;
5. Physiopathology of injuries of the spine and spinal cord;
6. Laminectomy in the treatment of lesions of the spine and spinal cord;
7. The present status of treatment of fractures of the spine with spinal-cord injuries.

The subject matter is written in a lucid style. Each chapter is followed by a résumé, and the most important findings are printed in large letters. Numerous illustrative case reports are given in substantiation of the description of the types of fractures and various methods of treatment. The symptomatology of fractures, complications, and the indications for treatment are remarkably complete. The orthopaedic surgeon acquainted with Spanish would find the monograph very instructive and interesting.

ÜBER DIE ENTSTEHUNG, ERKENNUNG UND VERMEIDUNG DER POSTOPERATIVEN FERNTHROMBOSE (The Development, Recognition, and Prevention of Postoperative Peripheral Thrombosis). K. Lenggenhager. Leipzig, Georg Thieme, 1941. 2.85 marks.

In this sixty-three-page monograph dedicated to Prof. de Inervain, the writer summarizes an eight-year study of peripheral thrombosis. It is his belief that a thrombosis in the vein begins as an agglutination of the platelets. Injury to the endothelium of the vein plays no part in the localization of the thrombus; this is determined by a local slowing of the blood stream. The precursors of thrombin enter the blood stream from the operative or injured area. Fresh fibrin, which cannot be demonstrated by the Weigert-color reaction, is absorbed by the blood platelets. This agglutination of platelets and fibrin forms the basis of the thrombus. If the lumen of the vein becomes plugged, a red secondary thrombus then appears with only partial closure of the vein.

There is a great individual variation in thrombin formation. Some individuals have a thrombin which is active longer in their blood stream. The livers of different individuals also have a different capacity for the formation and activation of thrombin. Then there is the local slowing of the venous circulation,—more marked in the presence of varicosities and poor circulation.

Prevention of peripheral thromboses hinges upon the hindrance of the resorption of thrombin, and upon measures to improve the local circulation; but the neutralization of the thrombin is the most important. The thrombin resorption reaches its zenith about one hour after the operation.

There exist two antithrombin substances, heparin and hirudin. The latter in larger doses is toxic. The administration of heparin is given in older patients (over forty-five) by injection about the site of the wound at the end of operation; this provides slow absorption for several hours. Or it may be given one hour after operation intravenously, five hours after operation, and finally thirty hours after operation. At the Berlin Clinic since 1935, 9000 patients have been operated upon, and of the 2500 treated with this heparin prophylaxis, none have died of embolus.

Heparin therapy can also be used when the first signs of peripheral thrombosis appear and can be repeated in twelve hours. By this means much, but not all, thrombin in the wound can be neutralized. In addition, the circulation should be stimulated by deep-breathing exercises every half hour, and by passive stimulation with drugs.

ÜBER DIE SUBKUTANE TOTALE ACHILLESSEHNENRUPTUR UND DEREN BEHANDLUNG (The Treatment of Total Subcutaneous Rupture of the Achilles Tendon). Nils Silfverskiöld. *Acta Chirurgica Scandinavica*, LXXXIV, 393, 1941.

The writer reports four acute and three chronic cases of subcutaneous rupture of the Achilles tendon, reviews the literature, and proposes a plastic operation to reinforce the tendon suture. A flap three to four by ten centimeters of the posterior layer of the Achilles tendon was turned down and rotated on the distal pedicle so that the smooth outer surface remained posterior. It was sutured along the sides and to the attachment of the Achilles tendon. Such good results are obtained by the operative treatment that it should be preferred to the conservative.—*Walter P. Blount, M.D., Milwaukee, Wisconsin.*

ANTITUBERCULOUS IMMUNITY PRODUCED BY B C G VACCINE. J. Zeyland and E. Piasecka-Zeyland. *Acta Paediatrica*, XXVII, 393, 1940.

Zeyland and Piasecka-Zeyland of Posnan, Poland, attempted to determine whether specific immunity was produced by B C G vaccine. Experiments were carried out upon guinea pigs, giving to twenty animals twenty milligrams of a two-weeks-old B C G culture with two cubic centimeters of fluid intraperitoneally. In four weeks the intracutaneous tuberculin reaction was positive in these vaccinated animals. Subsequently all of the animals were given 0.01 milligram of a four-weeks-old culture of human tubercle bacilli.

One animal in each group died early without evident tuberculous infection. In the vaccinated animals, there was evidence of a relative immunity, shown by greater longevity. The vaccinated animals lived four times as long as the controls although all of them developed tuberculosis.

In a second experiment, fifteen of thirty guinea pigs were vaccinated as in the previous series and four weeks later gave a positive intracutaneous tuberculin reaction. Inoculation of these thirty animals with human tubercle bacilli showed a much slower development of tuberculous changes in the vaccinated animals.

Observations were made upon 438 vaccinated children in contact with infectious tuberculosis, of whom forty-three contracted the disease. The authors concluded that the B C G vaccination reduced focal tuberculous morbidity five-fold.—*J. G. Kuhns, M.D., Boston, Massachusetts.*

DIE "UNCO-VERTEBRALGELENKE" UND DIE "ARTHROSIS DEFORMANS UNCO-VERTEBRALIS" (The "Unco-Vertebral Joints" and "Arthritis Deformans of the Unco-Vertebral Joints"). Trygve Krogdahl and Olav Torgersen. *Acta Radiologica*, XXI, 231, 1940.

The authors call attention to the fact that at the lateral extremities of the upper surfaces of the lower cervical vertebral bodies, a vertical plate of bone is characteristically found. This portion of bone appears first to have been described by von Luschka in 1858 as the "eminentia costaria", or the "process uncinatus". He was of the opinion that these uncinate processes represented the remnants of the heads of the cervical ribs, which had become reduced to form the costal or anterior element of the lateral masses of the cervical vertebrae. With a correspondingly depressed portion of the inferior surface of the next overlying vertebra, these processes formed true joints which have been designated as unco-vertebral joints.

As a result of the studies of a number of specimens, the authors confirm this belief and show that these joints may be the site of an arthrosis which is characterized by osteophyte formation. They show that the uncinate processes form the medial and inferior boundary of the intervertebral foramen and, in the presence of exostoses, may cause pressure upon the cervical nerve root passing through the corresponding intervertebral foramen. This process forms the medial boundary of the vertebral canal through which pass not only the vertebral artery, but more especially the vertebral nerve. Exostoses, by narrowing the vertebral canal, may lead to the syndrome of the cervical sympathetic, described by Guillain, and, by narrowing the intervertebral foramen these exostoses may be responsible for causalgia in the distribution of the corresponding nerve.

The exostoses may be located at any part of this joint and may be demonstrated roentgenographically by frontal, oblique, and lateral views of the cervical spine. When the exostosis involves the anterior portion of the unco-vertebral joint, it is seen most characteristically in the anteroposterior and, to a lesser extent, in the oblique views. When the exostosis involves the posterior portion, it is seen most characteristically in the lateral and, to a lesser extent, in the oblique views. When all three views demonstrate narrowing of the intervertebral foramen, the presumption is that the exostosis involves the whole extent of the unco-vertebral joint. In any case the routine taking of oblique views is considered essential. The suggestion is made that in some cases x-ray therapy may lead to relief of symptoms.—*Henry Milch, M.D., New York, N. Y.*

RÖNTGENOLOGISCHE DIAGNOSE DER MENISKUSLUXATION IM KNIEGELENK OHNE VERWENDUNG VON KONTRASTMITTELN (Roentgenographic Diagnosis of Meniscal Lesions in the Knee Without the Use of Contrast Solutions). Trygve Krogdahl. *Acta Radiologica*, XXI, 335, 1940.

The author calls attention to the fact that with the extremity straight, abduction of the leg permits roentgenographic visualization of the medial meniscus. The procedure,

first described by Nordheim, consists in binding both knees together and forcibly abducting the leg. In this position, and with the central ray making an angle of 75 degrees to the horizontal, the roentgenogram readily demonstrates the shadow of the meniscus in those cases in which no fracture is present in the knee joint. The inability to visualize the meniscus under these circumstances is presumed by the author to be indicative of an effusion which may be so small as to be clinically unrecognizable. Normally, the space between the femoral and tibial condyles in this position is approximately two to three millimeters. If the space is larger on the roentgenogram, it may be presumed to indicate an injury to the collateral ligaments of the knee joint.—*Henry Milch, M.D., New York, N. Y.*

ARTHROGRAPHIC STUDIES ON THE ANKLE JOINT. C. J. Hausson. *Acta Radiologica*, XXII, 281, 1941.

The author studied forty-eight ankles by means of an intra-articular contrast medium. Three to six cubic centimeters of 35 per cent. solution of perabrodil were injected into the ankle joint after preliminary anaesthesia with novocain. In twenty-six cases, so-called normal arthrograms were obtained. In the rest, the author was able to diagnose ruptures at various parts of the capsular and ligamentous apparatus of the ankle.—*Henry Milch, M.D., New York, N. Y.*

MALIGNANT SYNOVIOMA. Charles W. Hutchison and David H. Kling. *The American Journal of Cancer*, XL, 78, 1940.

A case is described of malignant synovioma arising from a bursa at the medial aspect of the knee joint two years after trauma. The patient was a female, twenty-eight years old. Repeated excision and roentgenotherapy failed to prevent recurrences and lung metastases. Death occurred seven years after the first symptoms. The tumor showed the complex structure typical of synovial tumors, partly cystic and partly solid. The cysts contained a synovial-like fluid.

A roentgenogram and several photomicrographs illustrate the report, and there is a brief review of the literature and discussion of the histogenesis of the tumors.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

COMPLETE DISLOCATION OF THE KNEE JOINT. A REPORT OF SIX CASES WITH END RESULTS. Milton J. Wilson, Arthur A. Michele, and Edwin W. Jacobson. *American Journal of Surgery*, LII, 77, Apr. 1941.

Six cases of complete dislocation of the knee without complicating fractures were collected by the authors over a period of thirteen years. The authors discuss the anatomical factors involved in the injury. In three cases the dislocations were anterior; in one, lateral; in one, medial; and in one, posterior. All were males, ranging in age from fifteen to thirty-five in five of the cases; and one was sixty-three. All patients were treated by closed reduction and one was explored, but no reparative procedures were necessary. All reductions but one were followed with plaster casts, and no evidences of instability were seen as a result of tearing of the cruciate or collateral ligaments. The authors conclude that conservative measures are best, and do not advocate immediate suture repair of the torn ligaments.—*Custis Lee Hall, M.D., Washington, D. C.*

TIBIAL DEFECTS WITH NONUNION TREATED BY TRANSFERENCE OF THE FIBULA AND TIBIOFIBULAR FUSION. Henry W. Meyerding and James H. Cherry. *American Journal of Surgery*, LII, 397, June 1941.

The authors review the type of operation used first by Hahn in 1884, and later by Codivilla who devised the two-stage procedure used in this country by Huntington and Stone. Meyerding modified the procedure in certain cases by arthrodesis of the upper

and lower tibiofibular joints, stating that the advantages are that the entire blood supply to the shaft of the fibula is left intact, that the surgical approaches are outside the field of infection, if present, and that if a tibial graft is used, the fixation and stabilization will be greater. Fifteen cases are reported, five being due to hematogenous osteomyelitis, nine to fractures, and one to a pathological fracture following osteomyelitis. Eight cases were treated by fibular osteotomy and transplantation by the Huntington method, three by tibiofibular fusion, and three by combined fusion and osteotomy, with a fibular graft used in the same leg in one case. In five cases, recurrent drainage occurred, and in three, temporary peroneal nerve palsy resulted. The table of results indicates good results and the technique is clearly discussed. Weight-bearing should not be attempted until from six months to a year after the second stage of the operative procedure, and then with adequate support until the clinical and roentgenographic evidences of union are adequate for weight-bearing in each case. Good results were obtained in thirteen of the fifteen cases reported.—*Custis Lee Hall, M.D., Washington, D. C.*

A Critical Appraisal of the Leg Lengthening Operation. Beveridge H. Moore. *American Journal of Surgery*, LII, 415, June 1941.

End results of bone-lengthening procedures in fifty-two cases are studied with particular emphasis on gait and function of the extremity. Forty-one were in the lower leg, of which the cause of shortening was poliomyelitis; two were congenital; and two were due to epiphyseal damage from manipulative treatment of club feet. Nineteen of the patients operated upon since 1929 were considered to have passed the rapid growth of adolescence. The lengthening was from one and one-half to two and seven-eighths inches, as checked on roentgenograms. Consideration was given to maintenance of length, secondary development of deformity, changes in muscle power, and gait or function. Maintenance of length was quite uniform and three patients showed more rapid growth than the normal leg; and one, failed to maintain the leg equality. Improvement was, of course, noted in postural balance, due to leveling of the pelvis and lessening of scoliosis. Knock-knee and valgus of the foot was increased in eight patients, and some loss of ankle function was noted, also changes in gait from greater strain on the weakened hip abductors. Studies of the gaits of these patients showed that six were improved, nine were not improved, and four were worse, which led to the conclusion that the two elements of shortening and muscle weakness must be carefully evaluated, so as to make a more careful selection of cases.

Patients with weak hip fixators and quadriceps accounted for most of the less satisfactory results. No cases of non-union were found, only one case of bone infection, and only moderate bone displacement in the fragments. Foot displacement occurred in two cases, and foot stabilization was done after the lengthening was complete. Nerve disturbance of a temporary character was seen in two cases.

Contra-indications are old osteomyelitis and epiphyseal injuries where length cannot be maintained. In congenital shortening each case must be considered separately. The author does not consider the operation feasible in patients without enough power to walk without a brace. Best results are in poliomyelitis cases with enough power in the gluteus muscles to fix the pelvis against gravity when walking, and sufficient quadriceps power to extend the knee with several pounds' resistance to the ankle. In doubtful cases, the shoe should be built up to equal the proposed lengthening, and the resultant gait observed.—*Custis Lee Hall, M.D., Washington, D. C.*

Guide for Internal Fixation of Intracapsular and Intertrochanteric Fractures of the Femur. I. W. Kaplan. *The American Journal of Surgery*, LII, 443, June 1941.

Mechanically, the guide consists of a metal frame with V-shaped ends, notched at the bottom. One end is held at the juncture of the shaft of the femur and the greater

trochanter by the notched ends and the other below on the shaft of the femur. A handle is used to hold the guide and indicate thus the horizontal plane. The director is a square piece of metal between the two V's and guides the wire or drill. It is set on a pivot which can be adjusted at any angle, and set by a screw on its undersurface. The director is equipped with three openings so that double screws or a single wire may be used. The top half can be removed if two screws are used. An angle guide is used, and for most cases is set at 127 degrees, and 20 degrees of internal rotation allows for horizontal-plane adjustment of the device. This procedure has been employed in thirty-eight cases, and operative time has been reduced to from thirty-five to forty minutes.—*Custis Lee Hall, M.D., Washington, D. C.*

TREATMENT OF FRACTURES OF THE SHAFT OF THE FEMUR BY DOUBLE WIRE TRACTION. H. A. Swart. *American Journal of Surgery*, LII, 507, June 1941.

The use of skeletal traction in fractures of the shaft of the femur is reviewed. In the author's experience since 1935, the use of a Kirschner wire through the distal fragment and a Thomas splint with Pierson attachment resulted in upward bowing which persisted in spite of change of angle or manipulation, and usually resulted in open reduction. By the use of a second wire, placed through the proximal end of the distal fragment, and downward traction, reduction was obtained. In cases of displacement of the distal fragment posteriorly, traction with the second wire upward produced the necessary reduction. Six cases are reported, and two additional cases are mentioned, in which a third wire was used with a ventral pull on the distal end of the proximal fragment and a dorsal pull on the proximal end of the distal fragment. Results were reported as good.—*Custis Lee Hall, M.D., Washington, D. C.*

A REVIEW OF 58 CASES OF TABETIC ARTHROPATHY. Maurice M. Pomeranz and Abraham S. Rothberg. *American Journal of Syphilis, Gonorrhea, and Venereal Diseases*, XXV, 103, Jan. 1941.

The authors describe fifty-eight cases with unquestionable roentgenographic evidence of tabetic arthropathy, of the ninety which were seen at the Hospital for Joint Diseases during the past ten years. About 72 per cent. of the cases occurred in white males.

Of the nineteen cases with multiple involvement, in two the spine and hip joints were involved; in one, the knee and foot; in one, the hip and knee; and in one, the hip and pelvis. There were twelve instances of bilateral disease, in three of which the hips were affected; in four, the knees; and in five, the feet. Where bilateral disease occurred, the parts were not affected simultaneously.

In contrast to the generally accepted view, the authors found that pain was frequently a prominent feature—in many instances the sole reason for reporting to the hospital—that motion frequently increased the pain, and that rest gave great relief. They no longer believe that lack of pain is of diagnostic importance. It is probable that the persistence of pain is due to an incomplete destruction of the pain fibers in the column of Goll and Burdach or in the spinal thalamic tract. Absence of the knee jerks, the Argyll-Robertson pupil, ataxia, and the Romberg test, in this order, are the neurological criteria which substantiate the diagnosis. It is just as important to repeat the neurological examination as the serological tests, as definite signs of tabes may ultimately develop. Only 62 per cent. of the patients had positive serological tests, and a relatively high proportion were completely negative. In spite of the greater value of the spinal-fluid examination in tabes, spinal taps were not performed so frequently as blood tests.

The authors agree with many other observers that the roentgenogram often provides the first clue to the existence of syphilis. In the early manifestations of the disease the most constant finding is the accumulation of fluid within the synovial sac, but of greater

importance is the presence of a slight sclerosis of the bones comprising the joint, which may be so slight as to be overlooked or misinterpreted by the inexperienced.

In the advanced stages of Charcot's disease, there may be no osteoporosis, but in the early stage of the disease when pain is usually present, there is a variable degree, the roentgenographic appearance of which is considerably modified by the associated syphilitic osteosclerosis.

Callus formation may be excessive where the fractures extend into the shaft, but scanty or absent where articular surfaces are involved. There may be intramuscular or ligamentous ossifications of varying degree, forming a cuff of bone around the joint, most characteristically about the knee and hip.

The differential diagnosis is chiefly concerned with the elimination of syringomyelia as a causative factor. Although the diagnosis of a neuro-arthropathy solely by the roentgenogram could be made without great difficulty as a rule, certain diseases at times simulated this condition rather closely. Chief among these were osteo-arthritis, pyarthrosis, neoplasms, and fractures about the joints.

In this group of cases twenty-one operations were performed on eighteen patients, two of whom died following knee fusions. Although a total of eleven fusion operations were performed, the only satisfactory results were obtained in the cervical spine, and one knee. It is too early to determine the outcome of one fusion operation in the lumbar region.

CRITERIO FUNCTIONAL EN EL EXAMEN PERICIAL DE LOS FRACTURADOS (Functional Criteria in the Critical Examination of Patients with Fractures). Oscar R. Maróttoli. *Anales de Cirugia*, VI, 369, 1940.

This article is an excellent discussion of how to grade a patient who has had a fracture, and who is ready to return to work. The author brings out the point that in the evaluation of residual disability in the final results from a fracture, the patient should be looked at from a broad point of view, including his ability both to do the kind of work he had been doing, and to adapt himself to a new type of work. He quotes a legal decision in support of this idea, and stresses the point that what he calls a physiological end result is very much more important than the anatomical result. We are all too prone to look at a roentgenogram and decide how much disability a man has, following a fracture, while in reality the roentgenogram is only a small part of the entire examination. Often those patients with roentgenograms which show quite a marked anatomical abnormality will have an excellent functional result. On the other hand, some patients in whom the roentgenogram reveals little or no anatomical disturbance have a great deal of loss of function in the extremity. This is particularly true of the upper extremities. The author quotes McBride in saying that there are three fundamental factors in the evaluation of the end result: mechanical and physiological alterations, the actual functional loss, and how much the patient can compensate or readjust for the loss. Another important factor which McBride points out is the possibility of the patient's receiving financial compensation for his injury. The author again stresses the fact that functional efficiency is much more important than the actual anatomical changes and presents several cases of fractures to illustrate his point. The article is a very good treatise on the critical evaluation of the end result in a patient with a fracture.—*Louis W. Breck, M.D., El Paso, Texas.*

PROTRUSIÓN ESENCIAL DEL ACETÁBULO (Protrusio Acetabuli). Oscar R. Maróttoli. *Anales de Cirugia*, VI, 395, 1940.

The author starts his discussion by saying that intrapelvic protrusion of the acetabulum is relatively infrequent, and, to his knowledge, there had been reported, up to the time of his article, only one other case in Argentina. The author presents two more cases whose histories are given in some detail. The first case was that of a woman, aged thirty, who had had pain in the hip for about one year. Examination revealed a good

deal of limitation of abduction and a moderate limp. Roentgenograms showed a bilateral protrusio acetabuli which was much worse on one side than the other. The second case was that of a twenty-three-year-old male who had likewise had pain in the hip for about one year. Examination of this patient revealed considerable limitation of motion in all directions with the limb held in flexion and adduction. Roentgenograms showed a marked intrapelvic protrusion of the acetabulum on one side, and a very slight degree of the same condition on the other. Following the case reports, the author describes briefly the condition with its pathology, the history of the discovery and recent advances in knowledge about it, and gives two classifications for intrapelvic protrusion of the acetabulum. The first classification is that of Golding, who divides cases into three groups; and the second is that of Julio Diez of Argentina, who simply divides the condition into two main types,—secondary protrusions and essential protrusions. The author is of the opinion that the intrapelvic protrusion of the acetabulum occurs usually without arthritis, but that arthritis deformans invariably begins in these patients after the age of fifty. He points out, however, that Ingerfeld reported a case with arthritis deformans in a patient with intrapelvic protrusion of the acetabulum at the age of twenty-one years, while one of the author's own patients was only twenty-two years old. The article is a very good discussion of the subject of protrusio acetabuli and the cases presented have good roentgenographic illustrations.—*Louis W. Breck, M.D., El Paso, Texas.*

EXTRASKELETAL OSSIFYING TUMORS. Harwell Wilson. *Annals of Surgery*, CXIII, 95, Jan. 1941.

Mesoblastic tumors containing bone occur, which have no connection with the skeleton. The author reports ten such cases and gives a synopsis of thirty cases of bone-forming malignant tumors in the soft tissues described in the literature.

Four of the ten cases reported were osteogenic sarcomata; one, a fibrosarcoma with degeneration, calcification, and heterotopic bone formation; one, a chondrosarcoma; one, a bursal sarcoma, with ossification in the primary tumor; one a case of von Recklinghausen's neurofibromatosis, with ossification in a neurofibroma; and two were fibrous osteomata.—*O. B. Bolibaugh, M.D., San Francisco, California.*

RUSSELL TRACTION IN THE TREATMENT OF FRACTURES OF THE FEMUR. OBSERVATIONS OF ONE HUNDRED FIFTY-SIX CASES. Kenneth M. Lewis. *Annals of Surgery*, CXIII, 226, Feb. 1941.

The author reviews the evolution of the treatment of fractures of the femur and points out the disadvantages of the various methods. The Russell method was adopted by the Fourth Surgical Division of the Bellevue Hospital in January 1930, because of lack of satisfaction with results obtained by skeletal traction. One hundred and fifty-six cases are reported in which this method was used: eighty-five intertrochanteric, twenty-three in the upper third of the shaft, eighteen in the middle third of the shaft, and thirty in the lower third of the shaft. Adequate reduction could not be obtained in seven cases, of which three were in the upper third and four in the lower third of the shaft.

Seventy-four cases were men and eighty-two, women. The youngest was fourteen years of age, the oldest eighty-six. The average period of traction was seventy-eight days, the shortest forty-two days and the longest one hundred thirty-five days. The weight used for traction varied from five to ten pounds. Reduction was checked by roentgenograms rather than by external measurements. There were six deaths, all in old individuals and caused by senility and bronchopneumonia. One hundred and forty-three cases which were treated by Russell traction alone were followed to an end result.

Reduction was easily accomplished and overriding corrected. Union was obtained in all instances. Traction was maintained until union was demonstrated clinically and by roentgenograms. The author states that few cases should be allowed unsupported weight-bearing under six months. Joint function was recovered more rapidly when this method was used.

The author concludes that Russell traction is the method of choice in intertrochanteric fractures and for all those involving the shaft. He recommends open reduction and internal fixation with a Lane plate when muscle interposition is present. The method is not recommended for intracapsular fractures of the neck of the femur. He believes that skeletal traction should be discarded as a procedure in handling femoral fractures.—*O. B. Bolibaugh, M.D., San Francisco, California.*

OBSERVATIONS ON TUBERCULOUS DISEASE OF THE SPINE IN MADRAS. N. S. Narasimhan. *The Antiseptic*, XXXVII, 698, 1940.

The author discusses his observations on tuberculous disease of the spine in Madras, where in the past three years he has treated 188 cases of vertebral tuberculosis as against 195 cases of tuberculosis of all other bones. The maximum incidence was in children between two and five years, and boys were more often affected than girls. The majority of cases were in the thoracic region, with the eighth to the twelfth thoracic vertebrae most often involved, and the twelfth thoracic vertebra more often affected than any other. The lesions were more often central than periosteal. Multiple infections of the vertebrae were common, and the articulations of the heads of the ribs were often involved.—*Robert M. Green, M.D., Boston, Massachusetts.*

DISLOCATION OF THE RADIUS ASSOCIATED WITH FRACTURE OF THE UPPER THIRD OF ULNA. M. G. Kini. *The Antiseptic*, XXXVII, 1059, 1940.

Kini reports a series of 330 elbow injuries, in ten of which dislocation of the radial head was associated with fracture of the upper third of the ulna. One of these cases showed radial paralysis. The author describes his technique of reduction, and recommends excision of the radial head when persistent redislocation occurs.—*Robert M. Green, M.D., Boston, Massachusetts.*

FRACTURED RIB WITH SOME OF ITS COMPLICATIONS. B. N. Sinha. *The Antiseptic*, XXXVI, 1083, 1940.

Sinha discusses the complications of rib fracture from direct and from transmitted violence. In the former, he recommends operative intervention to repair intrathoracic damage. The latter are best treated by immobilization with strapping for a period of from three to five weeks.—*Robert M. Green, M.D., Boston, Massachusetts.*

RÔLE OF SMALL-POX IN THE PRODUCTION OF DEFORMITIES BY CAUSING INFECTION OF BONES AND JOINTS. M. G. Kini and P. Kesavaswamy. *The Antiseptic*, XXXVIII, 169, Mar. 1941.

Kini and Kesavaswamy call attention to the occasional rôle of smallpox in the production of deformities by causing infection of bones and joints. During the past decade, the authors have seen twenty-one cases of osteomyelitis or arthritis associated with smallpox, and four with vaccination. The arthritic cases all ended in ankylosis. In the four cases of elbow ankylosis, excision gave satisfactory results. In all the hip cases pathological dislocation occurred, with absorption or other changes in the head and neck of the femur. The article is well illustrated and there is an excellent review of the literature.—*Robert M. Green, M.D., Boston, Massachusetts.*

CONGENITAL ELEVATION OF THE SCAPULA. Alan DeForest Smith. *Archives of Surgery*, XLII, 529, Mar. 1941.

The fifty cases of congenital elevation of the scapula seen at the New York Orthopaedic Hospital from 1912 to 1939 are tabulated and analyzed statistically. The de-

velopment of the deformity is traced phylogenetically, and the omovertebral structure is shown to be the homologue of the suprascapular bone found in several lower vertebrates. Surgical treatment was used in 28 per cent. of the cases and consisted of essentially three procedures: (1) removing the omovertebral connection; (2) freeing of the scapula subperiosteally, with excision of the upper part of the bone; and (3) freeing the bone and anchoring it at a lower level by suturing it to a rib. In general it was found that a number of patients were not sufficiently deformed to warrant surgery, but in the more severe forms of this condition the operative correction afforded improvement in a fair percentage of the cases.—*I. William Nachlas, M.D., Baltimore, Maryland.*

FRACTURES AND DISLOCATIONS OF THE CERVICAL PORTION OF THE SPINE. WITH A REVIEW OF EIGHTY-NINE CASES. William Arthur Clark. *Archives of Surgery*, XLII, 537, Mar. 1941.

In the study made of a series of eighty-nine fractures and dislocations of the cervical spine, it was found that minor trauma can produce dislocation alone, but that automobile accidents are responsible for most of the fractures. Neural complications were recognized by the presence of symptoms varying from slight tingling of the fingers to complete paralysis. Most of the injuries were found to be in the region of the fifth and sixth vertebrae.

Treatment consisted of various procedures: "extension of the head", followed by ambulatory support; manipulation, and application of cast; skeletal traction; and "expectant" (in cases of shock). The author feels that early reduction of the lesion is essential, since it may avoid a permanent paralysis through pressure on the cord.—*I. William Nachlas, M.D., Baltimore, Maryland.*

SECONDARY INFECTION IN TUBERCULOUS SINUSES. R. B. McMillan. *British Journal of Surgery*, XXVIII, 415, Jan. 1941.

From a study of non-pulmonary abscesses or sinuses in 132 patients, it was learned that tuberculous abscesses are free from secondary infection until they break through or are incised. A secondary infection was present in 90 per cent. of the sinuses studied; streptococci, staphylococci, and diphtheroid bacilli were predominant in that order.

Secondary infection seemed to occur from the surrounding skin, from neighboring sinuses, or from "droplet" infection, particularly if the organism was the streptococcus. The beta hemolytic streptococcus was the only organism that had any serious effect on the patient, but when this was present the prognosis became more grave, the period of hospitalization was increased, and the general health of the patient became poorer. In a few instances it was evident that the local and general spread of the tuberculosis had increased.

The secondary infection had no effect on the healing of the sinuses, which healed when and if the primary focus healed.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

CARTILAGINOUS TUMOUR OF THE SHAFT OF THE ULNA. T. Vibert Pearce and Douglas H. Collins. *British Journal of Surgery*, XXVIII, 432, Jan. 1941.

This is a case report of a cartilaginous tumor of the shaft of the ulna, appearing in a boy of sixteen, apparently after being hit by a cricket ball. The lump was noticed the same day that the trauma occurred, but there was "no bruising" of the arm. He applied for treatment two months later because of pain in the forearm, difficulty in writing, and limitation in pronation of the wrist.

A roentgenogram showed "a rarefied tumour expanding the cortex of the ulnar shaft on its dorsolateral aspect". On admission for operation six weeks later, there had been a marked increase in size of the tumor. The tumor was separated from the extensors of the thumb, outlined above and below by saw cuts, and removed with a chisel.

The tumor was partly covered by cortical bone with normal bone lying between it and the medulla, and was composed of adult cartilage in the deep layer, a small zone of foetal type of cartilage, a zone of myxomatous connective tissue, and finally a segment of collagenous fibrous tissue. Microscopically, no mitoses were seen. It was considered that this was a benign tumor beginning to show malignant changes.

Normal function was gained, and three years later there was no recurrence.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

TRATAMIENTO QUIRÚRGICO DE LOS TUMORES DE CÉLULAS GIGANTES DE LOS HUESOS (Surgical Treatment of Giant-Cell Tumors of the Bones). Alberto Inclán. *Cirugía Ortopédica y Traumatología* (Habana), VIII, 63, 1940.

The author reports a series of cases to demonstrate and explain the different surgical procedures to be considered in the treatment of giant-cell tumors of the bones. In two of these cases, the tumor was located at the patella, a very rare type which has been reported only fourteen times in the literature.

Bone tumors presenting a benign aspect, clinically, roentgenographically, and pathologically, may be treated by curettage, curettage with bone graft, or removal and bone graft on condition that the whole tumor is removed, and primary cicatrization is obtained.

Mass resection is indicated in recurrence of local malignancy, and in the so-called "aggressive type" when its malignancy is confirmed clinically and roentgenographically, as well as pathologically. The bone defect must be filled in order to maintain the form and length of the bone and to assure weight-bearing, even at the expense of some degree of limitation of movement of the joint or, if unavoidable, of total loss of movement.

Amputation should never be performed, except on those patients who are referred to the surgeon too late, or who are bearers of a secondary infection following unsuccessful curettage, or when there is no doubt regarding malignancy, as in bone sarcoma.

ESTADO ACTUAL DE LA CIRUGÍA DE LA CADERA EN LAS INSUFICIENCIAS INVETERADAS CON GRAN CLAUDICACIÓN (On the Present State of Hip Surgery in Severe Limping). René Charry. *Cirugía Ortopédica y Traumatología* (Habana), VIII, 37, 1940.

The author analyzes the conditions favoring the development of severe limping, and stresses that an efficient treatment must be logical and directed against each of its three elements: limp, pain, and fatigue. On the grounds of these results, he recommends a low shelf osteotomy of support, straightening osteotomy, shortening of the extremities for inequality in length, and drilling of the neck in arthritis deformans.

He follows his own technique, when establishing the low shelf without section of the glutei, and employs the wire method and malleable osteosynthesis plates for osteotomy.

The drill hole is centrally placed, and dead bone is used for nailing.

For the shortening of the sound limb, he uses his own technique which is a modification of that employed by Hugo Camera.

The results are excellent from the point of view of appearance.

For malunion of fractures of the femoral neck, he employs the same methods as for congenital dislocation, but obtains better function of the limb by using the trochanteric osteotomy.

THE TREATMENT OF FRACTURE OF THE EXTERNAL TIBIAL CONDYLE (BUMPER FRACTURE). Joseph S. Barr. *Journal of the American Medical Association*, CXV, 1683, 1940.

This type of injury is due to a blow on the anterior aspect of the knee, a fall from a height, or a twisting injury. The fracture is a comminuted one, with a large triangular fragment which is laterally displaced, and several smaller central fragments which are compressed downwards. The treatment is divided into three types according to the severity of the injury:

1. When the depression of the condyle is less than one-quarter inch, the leg is immobilized until the swelling in the knee subsides, then mobilization is carried out. When weight-bearing is resumed, a brace with knock-knee pad is applied and used for from two to six months.

2. When the condyle is depressed one-quarter to one-half an inch, it is considered a borderline case. Results are about equally good in patients treated conservatively and those operated upon.

3. When the depression is over one-half an inch, surgical restoration is advised. Through a curved lateral parapatellar incision the knee joint is exposed first. Then the fracture site is exposed by subperiosteal stripping, and fragments replaced so that the articular surface is restored. While held in this position, they are fixed by passing a bolt transversely through the fragments and upper end of the tibia. In the cases so treated, good results were obtained.—*L. J. Levy, M.D., Dallas, Texas.*

TREATMENT OF FRACTURES OF ULNA WITH DISLOCATION OF HEAD OF RADIUS (MONTEGGIA FRACTURE). J. S. Speed and Harold B. Boyd. *Journal of the American Medical Association*, CXV, 1699, 1940.

In discussing the Monteggia fracture, the authors emphasize the strong tendency toward radial deviation at the ulnar fracture site with subsequent subluxation or recurring dislocation of the radial head. In treatment of acute fractures in adults, closed reduction can frequently be satisfactorily accomplished, but seldom gives good final results because of the radial angulation at the ulnar fracture site with subsequent subluxation of the radial head. For this reason, they prefer open reduction, fixation of the ulnar fragments with a vitallium plate, and the securing of the radial head firmly with a fascial sling. This procedure is performed readily by the exposure the authors have devised, and without injury to the radial nerve. In acute fractures of this type in children, closed reduction is frequently satisfactory, but if reasonable reduction is not obtained, surgery is advisable.

In treating cases of non-union and malunion at the ulnar fracture site, an onlay graft, fixed with vitallium screws, is their method of choice. If the radial head is too roughened or cannot be reduced, the authors excise it. They have not found the results following excision of the radial head to be of sufficient moment to contra-indicate the procedure.—*Louis J. Levy, M.D., Dallas, Texas.*

TREATMENT OF COMPOUND FRACTURES IN WAR. REPORTS OF PRACTICAL EXPERIENCE IN THE SPANISH CIVIL WAR. Leo Eloesser. *Journal of the American Medical Association*, CXV, 1848, 1940.

Due to the difference between modern methods of warfare and those of years ago, the war surgeon found it necessary to revise his methods of treatment of the war injured. Means had to be discovered for rapid evacuation of patients with a minimum of postoperative care.

The author found that chlorinated lime was the most satisfactory, easily procurable and easily transportable skin disinfectant. The surgeon works a paste of chlorinated lime into the hands and often has only a thin trickle of water for rinsing purposes. Finally alcohol, or iodine-alcohol, or a mercurial in alcohol-acetone is used. The patient's skin is prepared with this chlorinated-lime paste, followed by iodine. Large drapes are dispensed with, and small yard-square drapes are used to surround the operative area.

Morphine, procaine, evipal, and pentothal sodium are used together with light ethyl chloride for anaesthesia. Roentgenograms are not used at all at the front as most injuries are compound and condition and position of fragments are revealed at the time of débridement.

The author favors thorough débridement and allowing the wound to remain open. He warns against placing sutures in the depths of the wound.

He discusses in great detail the emergency treatment of nerves, tendons, and damaged vessels, and the application of plaster splints and casts.—*Maurice Jacobs, M.D., Dallas, Texas.*

SPONTANEOUS REDUCTION OF CERVICAL SPINE DISLOCATIONS. J. T. Nicholson. *Journal of the American Medical Association*, CXV, 2063, 1940.

The author first presents a thorough discussion of the anatomy, etiology, and diagnosis of cervical-spine dislocations, with special reference to the upper portion of the cervical spine.

In reducing these dislocations, the author's method is to place the patient on his back on three mattresses so that his head hangs free over the upper edge. In such a position the weight of the head acts as traction, and this pull in the hyperextended position "spontaneously" reduces the dislocation.

The author found that this procedure was most satisfactory for spontaneous dislocations. It did not work well in traumatic cases, and in these, the hazard of increasing cord oedema by the dependent position contra-indicates this method during the first one to two days following injury. Posterior dislocation is also a contra-indication. A complication encountered was oedema of the scalp in one patient.

After reduction is accomplished, in forty-eight to seventy-two hours, a head and body plaster jacket is applied and kept on for twelve to sixteen weeks. This is followed by a Thomas collar which allows the strengthening of the neck muscles before leaving off all support.—*Louis J. Levy, M.D., Dallas, Texas.*

EARLY OPERATION (SPINE FUSION) IN UNSTABLE LUMBOSACRAL JOINTS. Gilbert E. Haggart. *Journal of the American Medical Association*, CXV, 2129, 1940.

The author again calls attention to the almost unlimited possibilities of interpretation of backache, and the lack of agreement among surgeons in regard to the pathogenesis of low-back pain. He groups the cases as follows: Group I, older persons who have received conservative treatment over a period of years; Group II, younger patients treated by arthrodesing operations. No case was included which suggested the diagnosis of ruptured intervertebral disc.

The author discusses the subject of congenital anomalies of the low back, and states his adherence to the belief that such anomalies do produce symptoms through faulty mechanics or when the ligaments and muscles become "decompensated". He lists the mechanical faults as unstable lumbosacral facets, bone defects in the posterior elements of the lumbosacral vertebrae, transitional vertebrae, spondylolisthesis, abnormally acute lumbosacral angle and posterior displacement of the fifth lumbar vertebra on the sacrum, and narrowing of the lumbosacral disc.

He concludes that most patients who do not respond to conservative treatment should be fused. In retrospect, he concludes (1) that patients receiving compensation should not be fused until after a settlement has been made; (2) that no emotionally unstable or psychiatric patients should be fused; and (3) that elderly patients should not be fused.—*Maurice Jacobs, M.D., Dallas, Texas.*

DIASTASIS OF THE DISTAL TIBIOFIBULAR JOINT AND ASSOCIATED LESIONS. Rufus H. Alldredge. *Journal of the American Medical Association*, CXV, 2136, 1940.

This type of injury is usually associated with extensive ligamentous rupture, and results from external rotation on abduction injuries at the ankle. It may or may not occur with a fracture.

The author briefly discusses the anatomy of the distal tibiofibular and ankle joints, and indicates that there is an upward gliding motion of the fibula on the tibia in dorsiflexion of the foot, resulting in a widening of the mortise; and a downward motion of the fibula on plantar flexion, with a narrowing of the mortise.

The diagnosis is made by roentgenogram, which shows a widening of the space between the internal malleolus and the internal aspect of the talus, and indicates a rupture of the internal lateral ligament and tibiofibular diastasis.

Treatment consists of reduction, closed or, if this is impossible, open, with internal fixation and immobilization for from twelve to sixteen weeks.—*Maurice Jacobs, M.D., Dallas, Texas.*

IMPROVED TECHNIC FOR REMOVAL OF SEMILUNAR CARTILAGE AND POSTOPERATIVE TREATMENT. Harold R. Bohlman. *Journal of the American Medical Association*, CXV, 2243, 1940.

In discussing his technique for removal of semilunar cartilages, the author believes that local anaesthesia is preferable to spinal or general anaesthesia; he does not employ a tourniquet for the operation. A careful study of the patient is carried out before surgery, with special reference to bleeding time, clotting time, etc., and complete hemostasis is obtained during operation by means of electrocautery. Aspiration of the joint, followed by air injection, is sometimes done at the close of the operation, and frequently when the sutures are removed on the sixth day. Motion and partial weight-bearing are started at this time. Recovery is usually complete in three weeks.—*Brandon Carrell, M.D., Dallas, Texas.*

THE MEDICAL MANAGEMENT OF FRACTURES. Charles F. Nelson and Roland C. Nelson. *Journal of the American Medical Association*, CXVI, 184, Jan. 18, 1941.

The authors offer some suggestions as to the medical management of fractures, based on the study and management of 1,000 fractures without a failure in union, on the forced regeneration of some fractures with greatly delayed union, cases of osteoporosis, Paget's disease, etc., and on animal experimentation.

They recommend blood-chemistry determinations early in all fracture cases, so that accurate medical management can be instituted. The object of the medical management is to establish a serum-calcium concentration of from ten and five-tenths to twelve milligrams per 100 cubic centimeters, and a serum phosphorus of from three and five-tenths to four milligrams with a calcium-phosphorus ratio of three to one. In addition to milk and calcium medication (one quart of milk daily, calcium gluconate intravenously and four grams of powdered calcium gluconate in four ounces of water twenty minutes before meals), they suggest the use of parathyroid solution to assist in calcium metabolism. For phosphorus metabolism a diet high in phosphorus (liver, eggs, fish, cheese, etc.), supplemented by vitamin D, is advised. A normal amount of free hydrochloric acid in the stomach is necessary to assure absorption of calcium and phosphorus.—*Brandon Carrell, M.D., Dallas, Texas.*

CEREBRAL SPASTIC PARALYSIS. THE OBSTETRIC HISTORY OF ONE HUNDRED AND EIGHTY-FIVE CASES. Gerald W. Gustafson and George J. Garceau. *Journal of the American Medical Association*, CXVI, 374, Feb. 1, 1941.

The authors reviewed the birth history of 185 children with cerebral spastic paralysis. They found prematurity, with its associated fragility of the arteries, to be one of the most frequent etiological factors. Anaesthesia and analgesia were of little importance, and are sometimes definitely useful in preventing cerebral damage. The birth history was normal in the majority of cases, and many infants had no clinical evidence of respiratory difficulty following birth. In these cases, the authors assume an actual lack of cerebral development as the cause of spastic paralysis.

The authors conclude from their results that proper management of labor constitutes the best prevention of spastic paralysis. This is especially emphasized in restricting the use of solution of posterior pituitary, which was an etiological factor in 13 per cent. of

the series. The authors feel that the prevention and treatment of premature labor is the greatest single factor in prevention of cerebral injury.—*Louis J. Levy, M.D., Dallas, Texas.*

MODERN TREATMENT OF COMPRESSION FRACTURE OF THE SPINE. P. C. Sanyal. *Journal of the Indian Medical Association*, X, 105, 1940.

Sanyal presents an interesting discussion of the modern treatment of compression fractures of the vertebral bodies. He describes his technique of hyperextension with suspension, but fails to mention the Rogers apparatus so effectively used in this country.—*Robert M. Green, M.D., Boston, Massachusetts.*

PATELLAR ADVANCEMENT OPERATION. A REVISED TECHNIC. Fremont A. Chandler. *The Journal of the International College of Surgeons*, III, 433, 1940.

In spastic paralysis the abnormally "high patella", resulting from elongation of the patellar tendon, has been successfully corrected by transplanting the bony insertion of the ligament downward. It has, however, been found that there may result an arrest in the growth of the anterior portion of the upper tibial epiphysis. Furthermore, the operation is considered more complicated than necessary.

In place of this procedure, the author presents a new technique for "advancing" the patella. The patellar tendon is exposed and split longitudinally in its mid-line and strips of tendon are partially freed from the split surfaces. The patella is then pulled down by a wire, running through it horizontally and anchored to the tibia below the tuberosity. The relaxed patellar tendon is then plicated and reinforced with the freed tendinous strips.—*I. William Nachlas, M.D., Baltimore, Maryland.*

TUBERCULOSIS OF BONES AND JOINTS. N. S. Narasimhan. *The Medical Practitioner*, XI, 379, 419, 1940.

From his orthopaedic clinic at Madras the author reports *in extenso* on his experience in the treatment of bone and joint tuberculosis. He points out the difficulties in early diagnosis and emphasizes the contra-indication of massage, manipulation, and passive movement. In 90 per cent. of his cases he has found previous contact of the patient with open cases of pulmonary tuberculosis, and urges the importance of avoiding such contacts as a means of prophylaxis.—*Robert M. Green, M.D., Boston, Massachusetts.*

ÜBER DIE HÄMATOGENE OSTEOMYELITIS (Hematogenous Osteomyelitis). Richard Bertelsmann. *Monatsschrift für Unfallheilkunde und Versicherungsmedizin*, XLVII, 237, 1940.

On the basis of bacteriological investigations begun in 1902, the opinion is expressed that infection may occur during infancy. A latent infection may remain unnoticed throughout the entire life of the individual or, under favorable circumstances, lead to osteomyelitis. Injury can be recognized only as a predisposing factor in osteomyelitis, not as a cause, except under extraordinary conditions. Bacteriological examination of the blood is very essential for early diagnosis, for early treatment, and for differentiation between severe and mild forms of infection. General prophylactic measures, especially dietetic treatment, would be expected to reduce the number of osteomyelitic infections.—*R. J. Dittrich, M.D., Fort Scott, Kansas.*

VERLAUF UND BEHANDLUNG DER QUERFORTSATZBRÜCHE DER LENDENWIRBELSÄULE. (Course and Treatment of Fractures of the Transverse Processes of the Lumbar Spine.) F. A. Ostermann. *Monatsschrift für Unfallheilkunde und Versicherungsmedizin*, XLVIII, 1, Jan. 1941.

The author relates a personal experience. In 1915 he sustained an injury to the

lower spine, which resulted in severe pain for a period of ten days. Without any extensive investigation in diagnosis and with no treatment, the incident was forgotten after the symptoms subsided. About twenty years later, following the onset of severe pain on exertion, a roentgenographic examination revealed fracture of the transverse processes of the upper three lumbar segments on the right side. Since this discovery, the author has treated fractures of this type principally by withholding from the patient any information regarding the exact nature of the injury. Other therapeutic measures are immaterial. — *R. J. Dittrich, M.D., Fort Scott, Kansas.*

LESIONS ABOUT SHOULDER JOINT. A. Steindler. *Northwest Medicine*, XL, 3, Jan. 1941.

The author discusses in detail the various signs, symptoms, and pathological findings in subacromial bursitis, together with other conditions simulating bursitis. Frequent conditions are rupture of the supraspinatus tendon, and calcified deposits in frayed tendons and pathological bursae. The long head of the biceps is frequently a sufferer from tears and calcium deposits, which are often seen bilaterally.

The treatment is conservative, excepting in rare cases, as, for example, the "frozen shoulder" with severe adhesions and chronic thickening and "nictitating folds", with marked crepitus and calcium deposits. Torn tendons also require operation if they do not repair spontaneously. A summary of sixteen cases is given. — *Charles Lyle Hawk, M.D., Los Angeles, California.*

COMPENSATORY GROWTH OF LONG TUBULAR BONES FOLLOWING FRACTURES IN CHILDREN AND ITS CAUSE. I. S. Vengerovskiy. *Novy Khirurgichesky Arkhiv*, XLV, 310, 1940.

Of 1637 fractures of long bones in children up to twelve years of age, 678 were reexamined from several months to eight years after the fracture. The incidence of restoration of normal configuration was previously reported. In the present article a study of the restoration of length was made. It was found that the active compensatory growth of a shortened bone takes place during the whole period of growth of the child, but is most intense in the first two to three years after fracture. The rate of compensatory growth evidently does not depend on the amount of shortening, and at times results in overgrowth of the bone in length.

A brief recapitulation of the existing explanations of growth of fractured bones in length is given. Multiple observations of successive roentgenograms and experimental histopathological inquiries by the author convinced him that a great part of growth in length takes place at the fracture site and is interstitial in character. He believes that, although the regular bone growth plays a certain rôle, the part played by the increase in interstitial bone is most important.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

ON THE SIGNIFICANCE OF EARLY FUNCTION IN BUNNELL'S TENOPLASTY. G. F. Nikolaev. *Novy Khirurgichesky Arkhiv*, XLV, 327, 1940.

The problem of immediate, early, and late motion after Bunnell's tenoplasty is considered. The author's references include the findings and recommendations of American and other surgeons and also special studies made by Russian investigators. Examples are cited which show good function after a long period of immobilization, made necessary by the accidental paralysis of the forearm from the use of a tourniquet. Other cases are reported in which motion started early after operation not infrequently produced separation of transplanted tendons. The author reports a series of experiments on rabbits, which included operative procedures according to Bunnell's method; early mobilization produced by controlled electric stimulation in one group, and by immobilization in a second group; and parallel histological analysis of the operative sites at various time intervals in both groups. The results of the experiments proved that with early active motion the tendon suture may be inadequate, that motion in the early postoperative

stage is a disturbing factor in tendon regeneration, and that such early motion has no specific advantage in the prevention of adhesions. The author concludes that initial immobilization with subsequent guarded motion of the operated finger is the best procedure.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

UNCERTAINTIES IN THE PRINCIPLES OF OPERATIVE TREATMENT OF ACUTE HEMATOGENOUS OSTEOMYELITIS. V. P. Vosnesenskiy. *Novy Khirurgichesky Arkhiv*, XLVI, 22, 1940.

On the basis of observation of 839 cases of osteomyelitis in children, the author tries to find guiding principles as to the best method of treatment. There were forty cases of the fulminating type with a mortality of 87 per cent., for the treatment of which the author does not find any answer. All the other types he divides into two groups: (1) those with a rapid formation of one or several localized sequestra and, (2) those with immediate diffuse osteonecrosis without definite demarcation. In the first group, waiting and conservative sequestrotomies are recommended, but in the second, the use of conservative tactics is decidedly contra-indicated. The author finds that best results in the second group may be obtained by an "early secondary" subperiosteal resection of the involved bone. He calls it "early secondary" because it is preceded by an emergency single incision of the subperiosteal abscess. As soon after the incision as the primary acute stage is passed, and the roentgenogram shows the character of the process (a period of about three to four weeks), an extensive subperiosteal resection is performed. This treatment shortens the period of hospitalization and hastens regeneration of bone.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

GALEAZZI FRACTURE. S. A. Stepin. *Novy Khirurgichesky Arkhiv*, XLVI, 195, 1940.

The fracture of Galeazzi is located in the distal part of the forearm and consists of a fracture of the diaphysis of the radius about eight centimeters cephaled to the wrist joint and a dislocation of the ulnar head. Galeazzi fractures are considered rare. The mechanism is explained by the presence of the following factors during injury: change in length of the radius, interference with the parallel disposition of the bones of the forearm, interference with the synchronous motion of the radio-ulnar joints at the elbow and wrist, and interference with the normal leverage curves of the radius. The fracture is similar to the Monteggia fracture which is located at the proximal end of the forearm and consists of a dislocation of the radial head and a fracture of the ulna in its upper third. Both fractures are frequently accompanied by nerve lesions, the Galeazzi type involving the ulnar nerve at the ulnar head, the Monteggia type, the posterior interosseous branch of the radial nerve winding around the head and neck of the radius.

The treatment in fresh cases is closed reduction, or if unsuccessful, open fixation. In old unreduced dislocations of the ulnar head, various operative procedures are described, among which the author cites a restoration of the triangular ligament of the wrist, resection of the head of the radius, and two cases of Milch sling operation. However, in the presence of malunion of the radius or nerve involvement, the problem remains very complicated.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

L'HIPPOCRATISME DIGITAL UNILATERAL ET SA VALEUR DANS LES ANÉVRISMES DE L'ARTÈRE SOUSCLAVIÈRE ET DU TRONC BRACHIO-CÉPHALIQUE (Unilateral Hippocratic Fingers). M. Mariano, R. Castex, et Egidio S. Mazzei. *La Presse Médicale*, XLVIII, 931, 1940.

Classically, hippocratic fingers have been described as occurring in chronic diseases of the respiratory tract, in congenital cardiac conditions, in biliary cirrhosis, in chronic suppurations, etc. This type of drum-stick fingers is to be differentiated from the hypertrophic pulmonary osteo-arthropathy with roentgenographic evidence of bone changes.

Hippocratic fingers usually appear symmetrically on both sides. A case is presented

in which unilateral drum-stick fingers were found. The literature of similar cases is reviewed. When hippocratic fingers occur unilaterally, they are a symptom of aneurysm of the subclavian artery or of the trunk from which the subclavian arises. This sign is not pathognomonic of the condition, since it is found, according to Poland, in three out of 121 cases of aneurysm. In the typical case, no osteo-arthropathy is found. Some authors attribute the drum-stick formation to compression of the subclavian vein.—*Henry Milch, M.D., New York, N. Y.*

SUR LES ARTHROPATHIES MUTILANTES SYMÉTRIQUE DES EXTRÉMITÉS INFÉRIEURES ET LEURS RAPPORTS AVEC LA SYRINGOMYÉLIE (Symmetrical Mutilating Arthropathies of the Lower Extremities and Their Relationship to Syringomyelia). Ludo van Bogaert. *La Presse Médicale*, XLVIII, 1026, 1940.

The author reports a case which was characterized roentgenographically by fusion of the tarsus, and by an unusual symmetrical destruction of the metatarsal heads and osteolysis of the metatarsophalangeal joints. Clinically there appeared to be some loss of temperature perception in the big toes. Despite repeated negative tests for lues, the condition had been considered as a syphilitic arthropathy.

This diagnosis did not seem justified, and the author undertook a study of the family of the affected individual. Two other brothers were found to be suffering from mal perforant and other "structural disharmonies".

The author believes this condition is identical with the familial plantar mal perforant described by Nelaton in 1852. He is of the opinion that it really represents the atypical lumbar syringomyelia in which the neurotrophic manifestations are predominant.—*Henry Milch, M.D., New York, N. Y.*

DIAGNOSTIC PRÉCOCE DE LA TUBERCULOSE DU GENOU CHEZ L'ADULTE JEUNE, SES DIFFICULTÉS, LES ÉLÉMENTS LES PLUS FIDÈLES DU DIAGNOSTIC (Early Diagnosis of Tuberculous Gonitis in the Young Adult). R. Dubau et F. Bolot. *La Presse Médicale*, XLVIII, 1031, 1940.

Attention is called to the fact that early diagnosis of tuberculosis of the knee is impossible in a large percentage of cases. The sedimentation rate, the tuberculin test, etc., are not pathognomonic. The regional lymph glands are positive only when the diagnosis is clear on the basis of clinical observation. Even the roentgenogram of the joint itself is not entirely dependable.

In a strictly formal sense, positive diagnosis depends on the isolation of the tubercle bacillus, either from the fluid or from the synovial membrane. Under suitable precautions, synovial biopsy can be carried out without serious danger. In lieu of these positive diagnostic procedures, the authors suggest that a roentgenogram of the soft tissues by a soft-ray technique is far more instructive than the roentgenogram of the skeletal parts. Especially in the lateral view, the roentgenogram clearly reveals the evidence of a thickening of the synovial membrane. Characteristically, the anterior and the posterior portions of the synovial membrane appear as separate thickened layers, and are united above by a downward directed concavity. Between the quadriceps tendon and the anterior layer of the synovial membrane, a small triangular shadow with base on the upper pole of the patella, is to be seen. Between the posterior layer and the shaft of the femur, another triangle, base up, is to be seen.

This appearance is believed to be typical of tuberculosis and does not occur in other inflammatory or traumatic lesions.—*Henry Milch, M.D., New York, N. Y.*

SOLITARY MYELOMA OF BONE. A REVIEW OF THE ROENTGENOLOGIC FEATURES, WITH A REPORT OF FOUR ADDITIONAL CASES. L. W. Paul and E. A. Pohle. *Radiology*, XXXV, 651, 1940.

This article reviews the literature of the subject and reports four new cases. The lesion is rare, and is believed to be a true neoplasm, related to malignant lymphoma and a

variant only of multiple myeloma of the plasma-cell type. Myeloma seems to occur in varying degrees of malignancy, with generalization taking place early in some and late, or never, in others. It occurs most often in the fifth decade, involving usually the spine, pelvis, humerus, or femur. In its roentgenographic aspects it takes two main forms. One resembles a giant-cell tumor. The other is mainly osteolytic, but expansion of the bone may be present. The trabeculated, multicystic form tends to be more benign. Pathological fracture is frequent. The osteolytic type commonly involves the spine and may cross the cartilage from one body to another. Histologically, the plasma-cell type predominates.

It must be differentiated from giant-cell tumor, localized fibrocystic disease, metastatic malignancy, osteogenic sarcoma, and Ewing's tumor. The diagnosis must rest on biopsy.

The treatment is by surgery, or radiation, or perhaps best by their combination. Permanent cure is not often obtained, but palliation and prolongation of life are usually obtainable.—*Edward N. Reed, M.D., Santa Monica, California.*

MULTIPLE MYELOMA. Lyell C. Kinney. *Radiology*, XXXV, 667, 1940.

These are malignant osteolytic tumors arising from cells in the red bone marrow. By the time they are large enough to give roentgenographic findings, they are generally multiple in the involved bones, and usually occur in several different bones. Most of them are of the plasma-cell type. They are probably independent lesions, and not metastases. They may metastasize to the liver, spleen, and lymph nodes, but have not been found in the lungs. There are no characteristic symptoms, but pain is usually present, particularly after the frequently occurring pathological fractures.

Bence-Jones protein is present in the urine of from 50 to 65 per cent. of myeloma cases, but is not characteristic. The absence of Bence-Jones bodies is not significant, because they occur only intermittently in the early stages, and are absent in 30 to 50 per cent. of cases.

The bones most frequently involved are the spine, ribs, skull, and pelvis. Characteristic findings are small, multiple, clean-cut areas of bone destruction, with the appearance of having been punched out of otherwise normal bone. The lesion is purely osteolytic and does not produce bone reaction or sclerosis. There may be extensive destruction of vertebral bodies presenting no roentgenographic evidence until the cortex is involved. The ribs present diffuse mottling and demineralization, with frequent spontaneous fracture and at times complete destruction of a portion.

The osteolytic type of metastatic carcinoma closely simulates multiple myeloma and roentgenographic differentiation may be impossible. The reactions of osteitis and sclerosis frequently seen in and around metastatic lesions are never found in myeloma.

Biopsy is indicated if there is any question of multiple myeloma, and is frequently the only means of reaching an early accurate diagnosis.

The author reports four cases.—*Edward N. Reed, M.D., Santa Monica, California.*

THE GROOVED DEFECT OF THE HUMERAL HEAD. A FREQUENTLY UNRECOGNIZED COMPLICATION OF DISLOCATIONS OF THE SHOULDER JOINT. Harold A. Hill and Maurice D. Sachs. *Radiology*, XXXV, 690, 1940.

Studies of humeral heads which had been excised because of recurrent dislocation, before the advent of more conservative treatment for this condition, revealed the presence of a so-called "typical defect". This was located posterior and medial to the greater tuberosity on the posterolateral aspect of the articular surface of the humeral head. It is a wedge-shaped groove, averaging two and one-half centimeters in length, one and one-half centimeters in width, and three-quarters of a centimeter in depth. It is not usually demonstrable in roentgenograms made in the routine positions, but is readily brought out by a projection made with the humerus rotated strongly inward, which throws the

posterolateral border of the head into profile; and by a tangential view, obtained by placing the film on the top of the shoulder, with the tube lateral to and below the elbow, which brings out the width of the groove. These views show a flattening of the articular surface, or, in larger defects, an indentation or groove on a level with the greater tuberosity; and a sharp, dense line running downward from the top of the head parallel to the axis of the shaft. This "line of condensation" is the result of compression of the spongy bone previously occupying the space of the defect. Cystic changes, with borders of increased density, are often present in the posterolateral portion of the head, just beneath the articular surface.

The defect is undoubtedly the result of a compression fracture, the anterior rim of the glenoid being forced into the weak posterolateral portion of the head as it impinges in the position of anterior dislocation.

It is believed to occur in more than two-thirds of anterior dislocations of the shoulder. It is so frequently found in habitual dislocation that it is described as the "typical defect"; it may be an etiological factor in recurrence, and may lead to unsatisfactory results in operations for relief.

Eight cases are reported and illustrated.—*Edward N. Reed, M.D., Santa Monica, California.*

AGENESIA SACRO-COCCIGEA (ANCHIPODIA) [Sacrococcygeal Agenesis]. Bruno Valentin. *Revista Brasileira de Orthopedia e Traumatologia*, I, 415, 1940.

In this article Dr. Valentin reports two cases of this condition, in one of which the sacrum was entirely absent; in the other a rudimentary sacrum was present. A historical summary of this unusual congenital abnormality shows that in its complete form it is seldom compatible with life. Cases of "pelvis dyspygica" described by obstetricians during the middle of the past century are of clinical interest because of difficulty in parturition. The subject remained little understood until 1924 when French research workers established the theory of a syndrome due to the numerical reduction of the sacrococcygeal vertebrae. Since then the number of reported cases has increased rapidly. Feller and Sternberg were able to show from the embryological and pathological angles that this congenital defect belongs to the same class as the so-called sirenoids which are classified as median malformations of the posterior part of the body. To this group belong atresia ani and the formation of cloacae. These authors have helped to unify this entire group of congenital defects from the mildest, showing only a partial lack of the coccyx, to the most extreme type of monster.—*Leo Mayer, M.D., New York, N. Y.*

A PARATHYREÓIDECTOMIA NA MOLESTIA DE ENGEL-RECKLINGHAUSEN. APRESENTAÇÃO DE TRES OBSERVAÇÕES. (Three Cases of Recklinghausen's Disease, Treated by Parathyroidectomy.) S. Hermeto Junior. *Revista Brasileira de Orthopedia e Traumatologia*, II, 69, 1940.

The author emphasizes the interesting opinions of Erdheim, Maresch, Mandl, and Lievre. He explains the characteristics of Engel-Recklinghausen's disease as a syndrome of hyperparathyroidism, and describes his three cases. The first patient presented a generalized form of the parathyroid osteosis, and the value for blood-calcium was found to be twenty-two milligrams per 100 cubic centimeters of serum; the second patient was a woman with a unilateral form involving specially the left limb; and the third was a young man who had two pathological fractures. Unilateral parathyroidectomy was performed on all patients. In no patient has any adenoma been found, though a bilateral exploration was always made in an attempt to find it. Reoperation was performed on the first patient eight months after the first intervention, and a noticeable improvement has taken place.

Healing of the pathological fractures was observed in the third case and the young

man returned to work. Reoperation was performed in the second patient, but without improvement.—*Prof. F. E. Godoy-Moreira, São Paulo, Brazil.*

THE CLINICAL ASPECT OF GOUT. Terray. *Rheumatism*, II, 31, 1940.

An acute attack of gout usually appears about midnight or in the early morning. It is due to a precipitation into the affected joint of uric-acid crystals. Too little attention has been given to the sources of uric acid, and to the causes which produce precipitation at certain times.

Normally uric acid is broken down by catabolism into either carbon dioxide or oxalic acid. In gout the uric acid is deposited, without decomposition, in the tissues. By experimental work it has been shown that uricaemia is due to a disturbance of the renal-hepatic function. If a normal dog is injected with uric acid and urates, one sees these substances disappear in the tissues and appear in large quantities in the urine. If, by an Eck's fistula, the liver is thrown entirely out of the circulation, no such decomposition occurs. The true rôle of the kidney is that of elimination of the urea and urates received from the blood, whereas the hepatic function aids in the decomposition of the uric acid.

Rational therapy, therefore, must be based upon a stimulation of the renal-hepatic function, since through it is obtained the fundamental lysis of the uric acid.—*Harold M. Childress, M.D., Charleston, South Carolina.*

THE PRESCRIPTION OF MASSAGE AND WHAT THIS IMPLIES. James Mennell. *Rheumatism*, II, 52, 1940.

Massage and other forms of physical therapy are often prescribed by physicians who are totally ignorant of the exact benefits to be expected from this form of therapy. The registered masseur is at a disadvantage as he must follow instructions. The ideal method is for the physician and the masseur to collaborate on the patient's condition and thereby obtain not only more accurate diagnoses, but also markedly improved end results.

"Omnibus" diagnoses, such as tennis-elbow, lumbago, sciatica, or neuritis, are utterly useless. In such cases it is for the masseur to determine exactly the points of pain, the limitations of motion, etc., and to convey his findings to the physician. By this method an exact diagnosis may be made. For instance, fibrotic deposits are fertile sources of low-back pain. Their precise locations should be determined before the usual treatment of novocain injections and deep massage are instituted. In brachialgia the causative factor may be a malalignment of joint structures in shoulder, elbow, wrist, or fingers. This factor must be definitely localized and then, as a rule, treated by manipulation.

The author discusses at length massage, joint manipulations, and electrical treatments. Each has its place in the treatment of affected muscles and allied structures, but none should be used except by one well trained in physical medicine.—*Harold M. Childress, M.D., Charleston, South Carolina.*

MUSCLE PATHOLOGY IN ANTERIOR POLIOMYELITIS. ITS RELATION TO FUNCTION. Herbert E. Hipps. *Southern Medical Journal*, XXXIV, 135, Feb. 1941.

Through a grant from the National Foundation for Infantile Paralysis, an intensive study of the gross and microscopic pathology of poliomyelitic muscles has been made. During operations for paralytic conditions, incisions were enlarged to expose the entire muscle. Photographs, sketches, and notes were made. The muscle was tested by mechanical stimulation for its ability to contract, and its elasticity and degree of tension were noted. Microscopic sections were taken from various parts of the involved muscles. This article is well illustrated and several new operative procedures are suggested. Fifty per cent. of the patients operated upon showed an appreciable gain in the strength of the muscles.

This paper gives much food for thought.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

THE IMPORTANCE OF PRIMARY CARE IN THE TREATMENT OF COMPOUND FRACTURES. H. Winnett Orr. *Southern Medical Journal*, XXXIV, 315, Mar. 1941.

Every fracture should be reduced immediately. Then it should be properly immobilized. To prevent gas gangrene it is necessary to have an open wound, with good drainage and access of air to all parts of the wound. Many modifications of the Orr method have been proposed and tried out. None have given any better results than the original method. Chemotherapy has not been proved to be of any additional value, although the sulfur drugs have been used quite extensively in connection with the Orr treatment.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

CAR WINDOW ELBOWS. Howard B. Shorbe. *Southern Medical Journal*, XXXIV, 372, Apr. 1941.

Thirty-two cases of this injury are reviewed, twenty-four of which were compound fractures. Nerve involvement was common. The types of treatment used were: closed manipulation, skeletal traction, open reduction, excision, and later bone grafts. Osteomyelitis developed in eleven patients; gas gangrene developed in two, one of whom died; and three patients had amputations.

Final results were excellent in four cases (of which two had no fracture); good with useful range of motion and useful hand in five; fair with limited motion in elbow and weakness in nine; and poor with stiff elbows, nerve involvement, and slightly useful hand in four. Eight patients had an entirely useless extremity. Those receiving efficient early treatment gave the best results. After débridement, sulfanilamide was put in the wound, and the wound closed as much as possible. Reduction of fracture and skeletal traction usually proved the best method. Extensive comminution of lower end of humerus required removal of fragments and reshaping end of bone in some instances; in others the joint was excised. The best treatment is prophylactic.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

RESULTS OF ABDOMINAL STABILIZATIONS. George O. Eaton. *Southern Medical Journal*, XXXIV, 443, Apr. 1941.

This article reports results obtained by the Lowman abdominal stabilization operations for infantile paralysis. Twenty-four of these operations were done at the Children's Hospital School in Baltimore. Twenty-five per cent. showed an increase in muscle power; 15 per cent. showed no change; and 60 per cent. showed a decrease in muscle power under the fascia. The fascial reinforcement bands which have been transplanted for an average of five years were considered too taut in four cases and too weak in two cases. Their effect on scoliosis and kyphosis is discussed. Marked improvement in gait was noted in 50 per cent. of cases; the remaining 50 per cent. showed no change. Fifty per cent. also showed increased stability when sitting. Seventy-two per cent. believed they had been benefited by the operations. No patient felt that he was worse.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

ETHYL CHLORIDE SPRAY FOR SPRAINED ANKLES. Lewis Cozen and Benjamin S. Hollombe. *Surgery*, VIII, 468, 1940.

The authors describe a technique in which ethyl chloride spray is applied, usually in the area of the sinus tarsi because this is usually the most definite tender area, until the skin of the area is white. The patient is allowed to walk without support at once. If pain persists, strapping is indicated. The authors believe the mechanism of the relief obtained is on a basis of the "break up" in the vasomotor paralysis, which the authors believe causes the greatest portion of the pain and swelling.—*F. E. Thornton, M.D., Iowa City, Iowa.*

PATHOLOGIC STUDY OF HYPERTROPHIC ARTHRITIS OF THE HIP. Malcolm H. Sawyer and Ralph K. Ghormley. *Surgery*, IX, 381, March 1941.

Nineteen specimens of hypertrophic arthritis of the hip were studied and the pathological changes described.

The authors concluded that the initial degenerative changes appear in the cartilage and are characterized by fibrillation, pitting, degeneration of the cartilage cells, and increased calcification of the deeper matrix. The marginal cartilage proliferates and shows few of the signs characteristic of degeneration. As the cartilage disintegrates and is worn away, the bone is exposed and becomes eburnated with thickening of the subchondral plate and the subjacent trabeculae by means of intramembranous ossification. The subchondral plate may or may not be thickened. The trabeculae are almost never increased in size in those areas that are still protected by cartilage, and most formation of new bone in these areas is of the endochondral type. The normal marrow is replaced by fat or loose fibrous tissue which, in some instances, dedifferentiates into osteoid tissue. The synovial membrane is invaded by fibrous tissue with markedly increased vascularity. Little evidence was found to support the hypothesis that arteriosclerosis is an etiological factor of osteo-arthritis. Finally, no collections of lymphocytes were found, which are characteristic of the infectious types of arthritis.—*Edward L. Compere, M.D., Chicago, Illinois.*

THE TREATMENT OF TUMORS OF THE SHOULDER REGION BY INTERSCAPULOTHORACIC AMPUTATION. J. E. Strode and E. A. Fennel. *Surgery*, IX, 394, March, 1941.

The authors conclude that the indication for interscapulothoracic amputation is most often "a relatively benign radio-resistant tumor that cannot be widely enough excised locally, due to nearness to structures important to the arm, to prevent local recurrences; in other words, tumors that are locally malignant due to their anatomical location and not from their morphologic composition".

Two cases are reported in detail: one of a carcinoma which recurred first, after local excision, and again, after removal of the tumor mass and the scapula. Radium was used repeatedly, but unsuccessfully. Three years after the initial diagnosis, the arm, including the clavicle, was removed. Fifteen years after this last operation, the patient was alive and there were no recurrences.

The second case was that of a male, aged sixty-two years, with a fibrosarcoma which arose midway between the clavicle and the spine of the scapula. Local excisions and the use of radium were in each instance followed by recurrences. Interscapulothoracic amputation was performed March 7, 1939, and after two years there are no metastases or local recurrences of this tumor.—*Edward L. Compere, M.D., Chicago, Illinois.*

THE PATHOLOGICAL PHYSIOLOGY OF JOINTS. H. Kelikian. *Surgery, Gynecology and Obstetrics.* LXXI, 416, 1940.

The article includes a short historical note and a description of the origin and classification of joints. The components of the joints, which with the exception of nerve and nucleus pulposus arise from mesoderm, are discussed under their respective headings.

The histology and nutrition of hyaline cartilage, which is essential for the maintenance of the joint space and the gliding movements, are described. It has no nerves, lymphatics, or blood vessels, and plays a passive rôle in disease. It is affected secondarily by disease of its surrounding tissues, but primarily only by trauma. To live, hyaline cartilage needs healthy cartilage on the apposed surface. Changes characteristic of degenerative arthritis are caused by continued use of a damaged joint, and not by immobilization.

The articular ends of bones are composed of a cancellous interior and a thin coating of compact bone, with vascular connective tissue present only in the former. Bone

necrosis is caused by shutting off the blood supply, by exudative proteolytic ferments, and by activated osteoclasts, and may cause articular breakdown. The virulence of the invading organism, exudate, and mechanical contact and pressure within the joint modify the development of bony ankylosis. Functional adaptation is often seen in articular ends.

The joint capsule, consisting of an outer fibrous and an inner synovial layer, binds the bones together. The histology and function of the synovial membrane are excellently described. The internal stratum is like the articular cartilage structurally, functionally, and pathologically, while the external layer is analogous to the cancellous spaces of the bone ends. New growths may form in the synovial membrane.

The synovial fluid may be an exudate or transudate. It is alkaline in reaction and contains mucin, albumin, fat, and inorganic salts. It lubricates, protects against acid metabolites, and nourishes the articular cartilage. In disease it changes in composition, reaction, and amount.

The accessory structures—namely the fibrocartilages, ligaments, muscles, tendons, and bursae—are described anatomically, and their injuries and diseases are discussed.

The circulatory relations are described and show the very close relationship between blood plasma and synovial fluid.

The summary and correlation of the writer are excellent as are the numerous illustrations of the pathology described in the text. The content is so comprehensive that no review can do it justice.—*Richard McGovney, M.D., Santa Barbara, California.*

THE SUPERIORITY OF NEOARSPHENAMINE AND SULFATHIAZOL IN THE THERAPY OF STAPHYLOCOCCUS AUREUS INFECTIONS IN MARROW CULTURES. Edwin E. Osgood, Julia Joski, and Inez E. Brownlee. *Surgery, Gynecology and Obstetrics*, LXXI, 445, 1940.

The authors made an extensive study of the effect of sulfanilamide, sulfapyridine, sulfathiazol, sulfamethylthiazol, and neoarsphenamine on staphylococcus infection in marrow cultures. In marrow cultures neoarsphenamine in concentrations of 1:150,000 to 1:200,000 was most effective. Concentrations of 1:10,000 sulfathiazol and sulfamethylthiazol were of value, but seldom produced complete sterility. Sulfapyridine was only slightly effective, and sulfanilamide was practically ineffective. Concentrations of neoarsphenamine above 1:150,000 were toxic to marrow cells, and concentrations above 1:70,000 killed all cells.

The authors' studies suggest that administration of neoarsphenamine in intermittent courses of repeated small doses, together with sulfathiazol in doses sufficient to give a blood concentration of 1:10,000, is worthy of controlled clinical investigation in serious staphylococcus aureus infections.—*F. E. Thornton, M.D., Iowa City, Iowa.*

HAMMER-TOE: A NEW PROCEDURE FOR ITS CORRECTION. Seth Selig. *Surgery, Gynecology and Obstetrics*, LXXII, 101, Jan. 1941.

The writer describes a method for cure of hammer-toe by use of a Kirschner wire placed longitudinally through the three phalanges. Previous methods are enumerated, but not recommended for reasons given, chiefly that of postoperative immobilization.

Through a medial longitudinal or transverse incision, the proximal interphalangeal joint is exposed, cartilage removed, wedge taken if necessary for alignment and a 35/1000 Kirschner wire passed with a hand chuck longitudinally through the phalanges from the tip into the wound. The toe is then lined up axially and the wire driven to the base of the first phalanx. The joint surfaces must be flush. Special pliers are of assistance. The distal end of the wire is bent to a right angle to prevent wandering. Wire position should be checked by roentgenography. The patient is discharged the same day, resuming activity in cut-out shoes.

The operation has been done on twenty toes with bony union in all properly carried out. The article is well illustrated by line drawings and roentgenograms.—*Richard McGovney, M.D., Santa Barbara, California.*

LAS FRACTURAS DIAFISARIAS DEL FEMUR EN EL NINO (FRACTURES OF THE DIAPHYSIS OF THE FEMUR IN CHILDREN). P. S. Toledo and S. Sanchen. *Vida Nueva*, XLVI, 1, 1940.

A monograph presenting an analysis of 105 cases of fractures in children, illustrated by many photographs and roentgenograms. The conclusion of the study can be briefly summarized as follows: Treatment of these fractures should be considered emergencies. The best method of treatment is overhead traction in children under seven years of age, adhesive plaster traction for children above this age unless it is inadequate. If it is inadequate, skeletal traction is necessary. It is noted that skeletal traction at times produces lengthening of the extremity. Maintenance of the normal axis in fractures is more important than approximation of fragments. Poor anatomical or roentgenographic appearance is very often accompanied by excellent functional results. Open reduction is rarely indicated in recent fractures. The prognosis is good, if the traction method is used in the presence of proper indication and carried out meticulously under constant observation.—*Emanuel B. Kaplan, New York, N. Y.*

BEDROHLICHES AZETONERBRECHEN NACH ORTHOPÄDISCHEN EINGRIFFEN (Injurious Acetone Vomiting After Orthopaedic Operations). Karl Sell. *Zeitschrift für Orthopaedie und ihre Grenzgebiete*, LXX, 21, 1939.

The author discusses the very sudden appearance and the stormy course of this complication, its etiology, and treatment. The author emphasizes it particularly in sympatheticotonic individuals, and warns of the dangers, especially in such cases as the shelving operation of the hip in which the psychic element is greatly accentuated. The urine should be examined for acetone before the operation. The patient should not fast the day before the operation, but should be given sugar, fruit juices, and dextrose in large amounts, and ample amounts of vitamins C and B-1. Inhalation anaesthesia is to be given in conjunction with rectal anaesthesia of avertin. With all this precaution the author has not had any cases of acidosis with severe symptoms for a long time.—*A. Steindler, M.D., Iowa City, Iowa.*

DIE DIÄTBEHANDLUNG DER RHEUMATISCHEN ERKRANKUNGEN (Dietary Treatment of Rheumatism). W. Heupke. *Zeitschrift für Rheumaforschung*, III, 357, 1940.

Rheumatic diseases are frequently looked upon as allergic manifestations. Rossle and Klinge believe that rheumatic nodules are always allergic. If this is true, dietary regulation should be helpful. Our therapeutic approach in rheumatic diseases cannot be direct. We must attempt to elevate the resistance of the body and improve its ability to overcome the disease. For this, physical therapy with massage and baths is helpful, working through the superficial tissues. But the entire body economy must be influenced. As evidence of metabolic errors in rheumatic diseases, we have at times an elevated uric acid, a disturbed calcium exchange, and a faulty water balance. In England and America the Pemberton diet has been helpful. With the Roh diet long continued, and given in conjunction with physiotherapy, many chronic patients improve. This diet (percentages and calories not given) is poor in sodium chloride, rich in potassium, calcium, and magnesium. The protein content is decreased; and it is low in calories, but rich in vitamins. Where the appetite is poor and the patient does not wish to eat much, better progress will be observed by giving a salt-free diet or a vegetarian regimen than by giving the patient what he wants. No special diet will fit every patient and the diet must be modified for individual requirements.—*John G. Kuhns, M.D., Boston, Massachusetts.*